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# MODERN PLASTICS



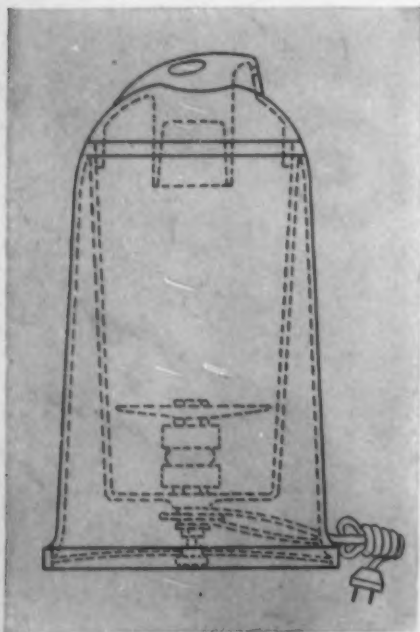
MAY 1944

# DESIGN DATA ON PLASTICS

V. Cool Thinking On A Hot Item

Most of the current plastic pieces which are of more than passing interest to design engineers necessarily come out of the "war zone". It is proper to so classify the DeVilbiss all-plastic vaporizer... the first of its kind... produced to combat the dangerous "bugs" of flu, pneumonia, bronchitis, etc. on the home front.

It is a piece worthy of study and explanation. The assembly consists of two



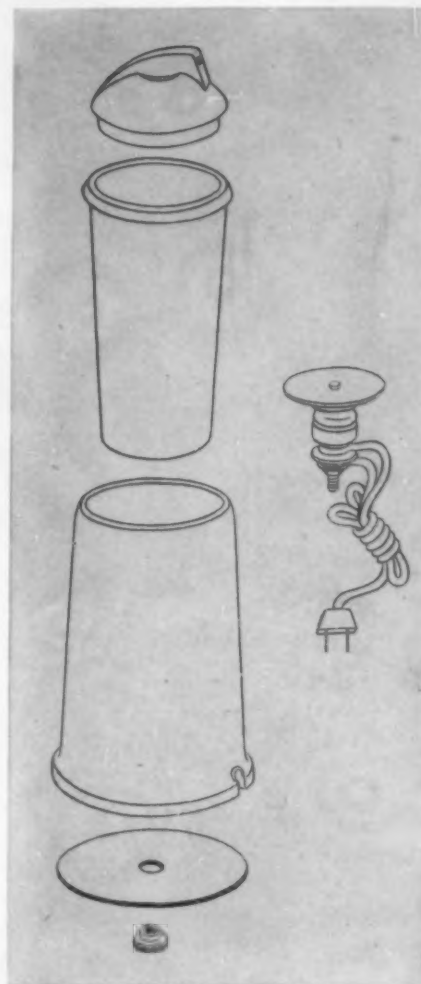
shells, a cover, shield plate, assembly bolt head, and locking nut...all molded from a Durez phenolic plastic... heating element and a porcelain washer. Ease of moldability in this Durez phenolic made possible certain complex molding operations.

Service requirements are severe. The material must take exposure to steam for hours at a time without affecting physical or electrical properties. It must withstand various medicants while in operation, and alcohol solutions are often used for cleaning.

A careful analysis proved a Durez 75 type of material to be "just the ticket". This phenolic is a high chemical-resistant material, having very low moisture absorption, and good molding characteristics. Skillful designing and the right choice of material have been combined into a product whose lines and finish have plenty of eye-appeal.

One important sales advantage the designer has achieved over previous types is that the user no longer has an ugly, discolored vaporizer on his hands after a few applications.

The success of the DeVilbiss vaporizer is the result of manufacturer, molder and material producer working together. We suggest such teamwork may add some-



thing to the solution of your own design and engineering problem. We offer the facilities and research of our technical staff in determining the material best suited to your purpose. Durez Plastics & Chemicals, Inc., 55 Walck Rd., North Tonawanda, N. Y.

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MOLDING COMPOUNDS  
AND RESINS

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By the sheer power of their color richness alone, these Catalin plastics will inspire a totally new conception of design value—Ranging from color transparents and delicately hued translucents to brilliant opaques, Catalin frees the reins of one's planning from the inception of the idea to the finished product—and at favorable cost.

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MAY 1944

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# Resimene

A NEW MONSANTO PLASTIC

## how it solves arcing problems in wartime electrical equipment NOW

HERE is an answer to the urgent need for an easily molded plastic with high arc-resistance—Resimene 803A, a cellulose-filled melamine-formaldehyde molding compound with high arc resistance and the moldability of a general purpose phenolic plastic.

Specifically, Resimene 803A has an arc resistance of 120 seconds (ASTM-D495-41) . . . excellent electrical insulating properties . . . and mechanical properties comparable or superior to general purpose phenolic plastics . . . yet in molding trials on AN connector inserts production rates set with a general purpose phenolic were easily maintained.

You will find Resimene 803A ideal for many aircraft ignition parts and wherever an electrical insulation is needed to withstand the higher voltage differentials and severe operating conditions commonly met by World War II electrical equipment.

Other characteristics of the entire family of Resimene molding compounds and industrial resins which will make them one of the most useful of all plastics once peacetime production is resumed:

- high heat resistance
- wide color range
- low water absorption
- good acid and alkali resistance
- good resistance to boiling water
- odorless, tasteless, inert to organic solvents
- hard, permanent surface
- high tensile and compressive strength
- good flexural strength

All Resimene molding compounds and resins are available now only for direct military applications . . . but a glance at the list of future uses to the right will show how important Resimene can be to your *postwar* plans. For more details, write: MONSANTO CHEMICAL COMPANY, Plastics Division, Springfield 2, Massachusetts.

## How it will solve many more design problems POSTWAR



Superior electrical properties will continue to be important in parts for aircraft and automobile ignition systems, circuit breakers, telephone handsets, etc., etc.



Excellent resistance to acids, alkalis and boiling water plus Resimene's color range and high abrasion resistance should lead to molded dishes, many kitchen articles.



Still another postwar possibility is incandescent light fixtures molded from Resimene. Here color range, heat resistance, moldability, would all be useful traits.



Resimene's ability to stand up under constant handling and exposure to weather plus its color range should make it possible to mold colorful, durable hardware.



Resimene bonding resins for plywood, fabrics and paper will be useful wherever a colorful surface with good abrasion and excellent weather resistance is desired.

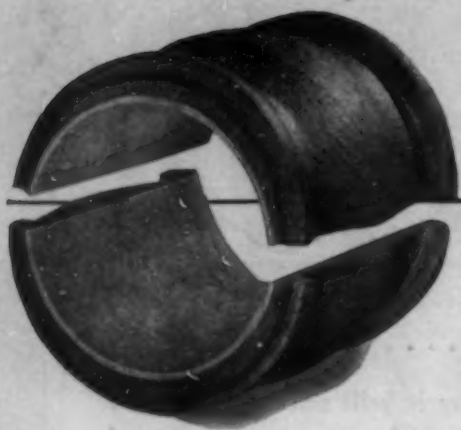


You will also probably see molded resin-fibre materials in which lower-cost phenolics will be combined with Resimene resins for a colorful and durable surface.

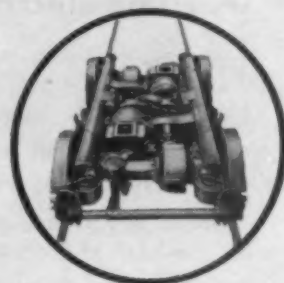
The broad and versatile family of Monsanto Plastics includes: Lustron polystyrenes • Monsanto vinyl acetals • Nitron cellulose nitrates • Fibestos cellulose acetates • Opalon cast phenolics • Resinox phenolic compounds and Resimene melamine compounds. Forms in which they are supplied include: Sheets • Rods • Tubes • Molding Compounds • Castings • Industrial Resins • Coating Compounds • Vupak Rigid, Transparent Packaging Materials.

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# How do temperature changes affect linear thermal expansion of Du Pont "Lucite"?

More data on Du Pont "Lucite" methyl methacrylate resin sheeting for aircraft designers, engineers and their established enclosure suppliers.

IT IS IMPORTANT that allowance be made for thermal expansion and contraction of plastic airplane enclosures subjected to wide changes in temperature due to altitude and geographical location.

The coefficient of thermal expansion

of "Lucite" differs so widely from those of metals commonly used in mounting structures that suitable adjustment of design is necessary. For instance, the linear thermal expansion of "Lucite" is 3 times that of aluminum . . . 8 times that of steel . . . and 10 times that of glass. A differential expansion of as much as 0.006 inch per linear inch may occur in the plastic at the extremes of temperature ex-

perienced by military aircraft. See graph and table (Fig. 1) for values of increase and decrease in length of cast "Lucite" bars over the temperature range of  $-80^{\circ}\text{C}.$  to  $+75^{\circ}\text{C}.$

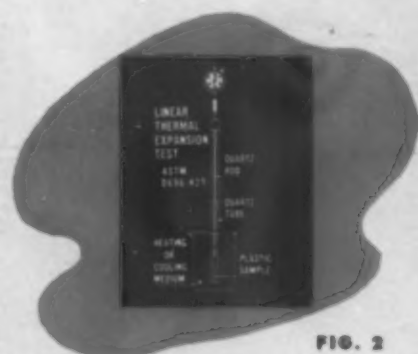


FIG. 2

## METHOD OF MEASURING THERMAL CHANGE OF "LUCITE"

Du Pont technicians measured temperature effects on the length of "Lucite" using a quartz dilatometer, consisting of a 24-inch vertical tube of fused quartz, of  $\frac{1}{16}$  inch i.d., closed at its lower end (Fig. 2). A sample of "Lucite" 3.74 inches long was placed in the tube, followed by a rod of fused quartz. The rod rested on the sample and transmitted changes in the length of the test bar to a dial gauge.

The lower end of the apparatus was placed in a container of liquid. Expansion and contraction measurements were obtained by heating the liquid electrically, and cooling with "dry ice." Results of tests applying this method of measurement were used to construct the curve of the graph (Fig. 1).

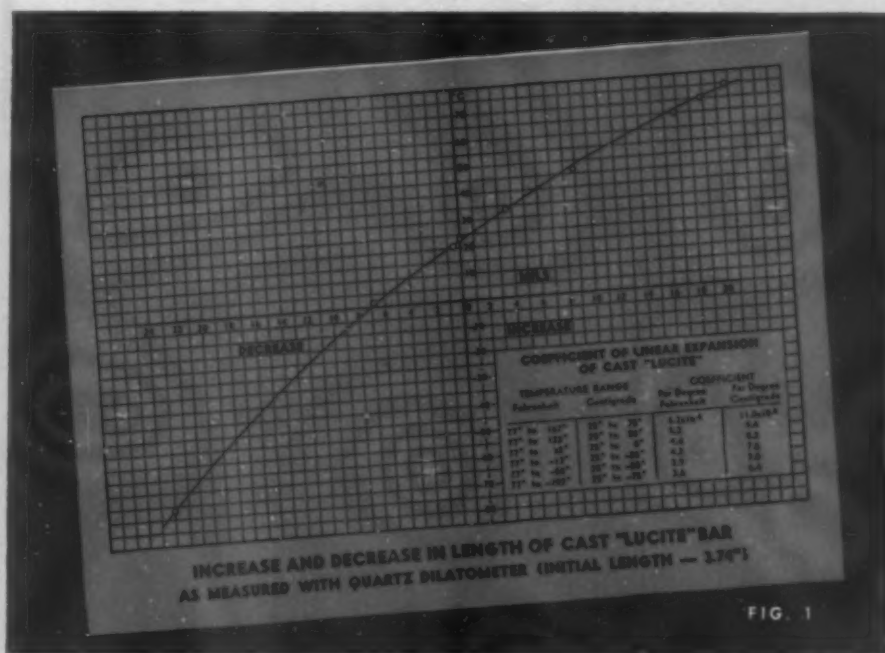


FIG. 1

## SEE THIS MANUAL FOR MORE DATA

Due to the linear thermal expansion of "Lucite," proper methods of mounting and installing enclosures of the plastic are very important. The 114-page aircraft Manual on "Lucite" includes detailed information on this subject . . . also on fabricating, forming, repairing and general properties of "Lucite." Get your free copy. Write on your business letterhead to E. I. du Pont de Nemours & Co. (Inc.), Plastics Department-R, Arlington, N. J., or 5801 South Broadway, Los Angeles.



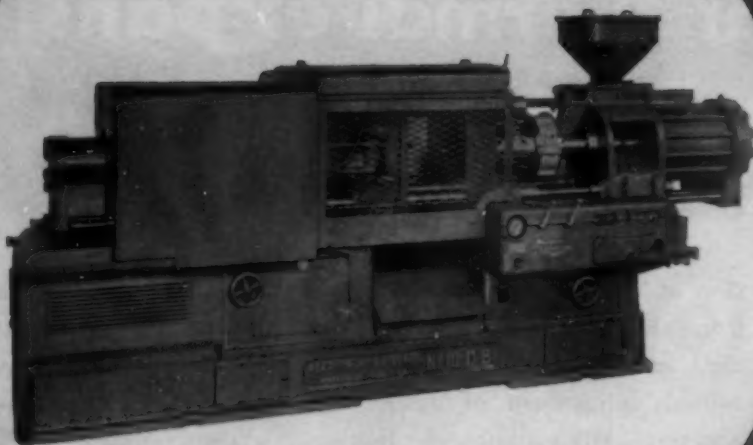
# "LUCITE"

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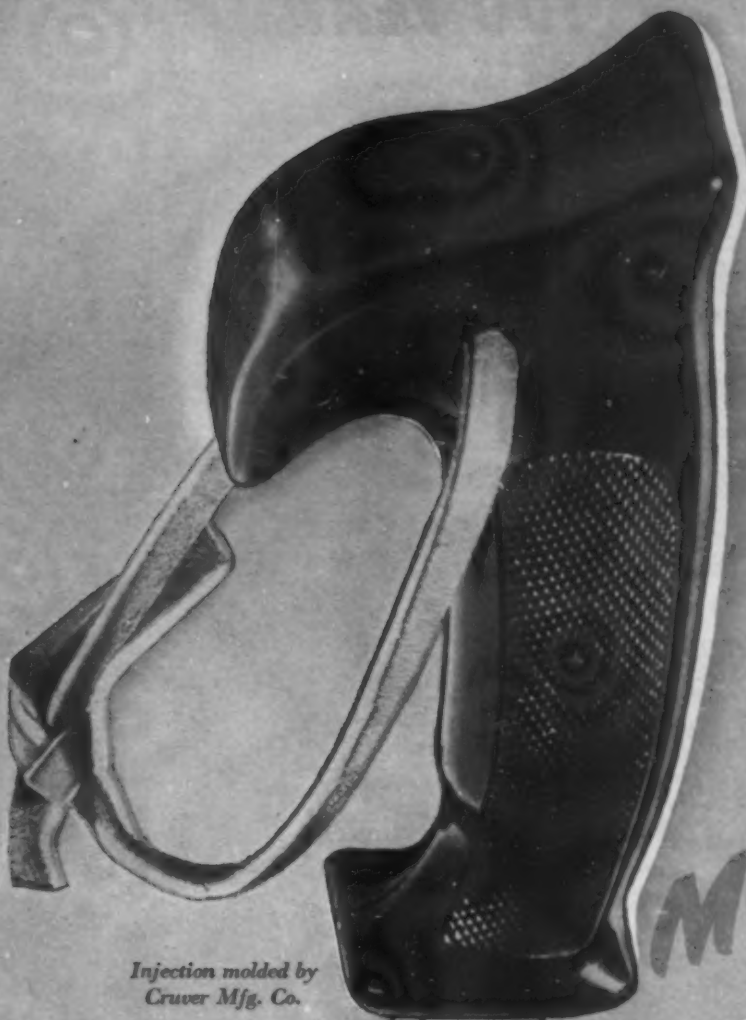
Assembly line production of our Injection Molding Machines pays handsome dividends to our customers. All of the skills acquired during 75 years of manufacturing high quality machine tools and our recently expanded manufacturing facilities, are valuable assets to every molder. Quantity production also offers the advantages of interchangeability and lower costs.

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For aircraft and automotive control wheels, grips, railings, cable pulleys and brackets, the combination of Lumarith and metal disposes of problems of strength and structure, and, at the same time provides for hand comfort and surface permanence.

The technical service division of Celanese Celluloid Corporation has accumulated data of interest to aviation manufacturers and automotive designers. Your inquiries concerning the full range of Lumarith plastics—their properties and applications—are invited. Celanese Celluloid Corporation, The First Name in Plastics, a division of Celanese Corporation of America, 180 Madison Avenue, New York City 16.

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1840 to 1855.  
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**Flexibility** — Revise layouts at will, to get best sequence of operations and break bottlenecks.

**Adaptability** — Small and compact, Delta machines can be added to present layouts to save waiting, to provide extra operations during idle time on automatic machines, etc.

**Special-Purpose Machines** — Use them freely — when you can build them so quickly at such little cost, out of standard Delta elements.

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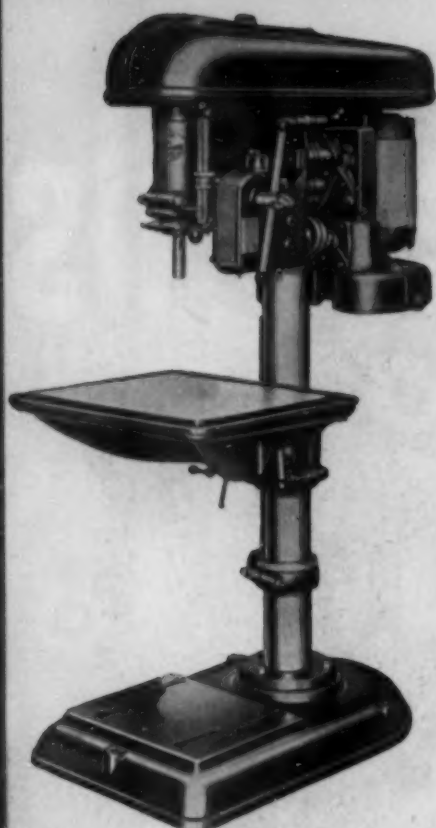
**Quantity Production** — Delta cost savings are due to modern production methods applied to a large volume of standard models — not to short-cuts in quality.

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... and here are the machines themselves **TURN THE PAGE**



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Worm-driven power feed operates directly off motor — giving 8 rates of feed for each spindle speed. One swift hand motion brings drill down to work. Automatic stop and spindle return. Instant switching from heavy power-feed operations to sensitive hand drilling. 17-inch single spindle drill presses available in 24 different models.



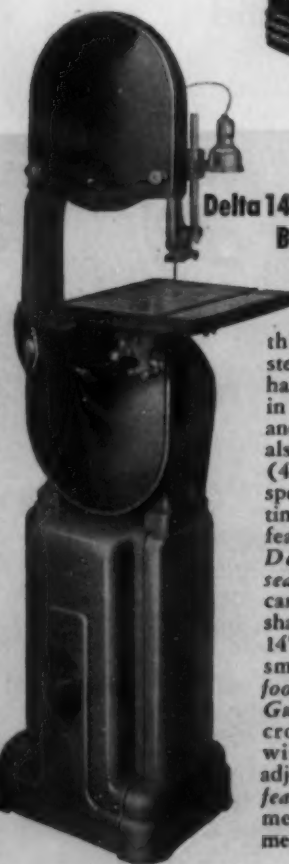
## Delta Floor-Type Multiple-Spindle Drill Presses

4-spindle model illustrated. 2-spindle model also available with one-piece table. Floor types with sectional tables: 3-, 4-, 5-, 6-, and 8-spindle.



## Delta 6" Abrasive Belt Finishing Machine gives you top efficiency

Handles dozens of sanding, polishing, and finishing operations — polishing and sizing metal parts, finishing and polishing die castings, finishing, fining and surfacing plastic parts, etc. Set horizontally with wood fence for edge or face sanding, or used vertically in connection with the 7½ x 14¾" tilting table. Completely equipped with double-seal ball bearings. Many other quality features.



## Delta 14" Metal-Cutting Band Saw

This low-cost, high-quality machine cuts anything from carbon steel to asbestos — has dozens of uses in the general tool and machine shop, also the pattern shop (4 metal-cutting speeds, 1 wood-cutting speed). Delta features: 10 New *Departure* Self-sealed ball bearings carry all wheels and shafts. Heavy table, 14" x 14", swings smoothly. Simple, foolproof gear drive. Guides give micrometer accuracy with independent adjustments. Safety features complete, meet all requirements.



## Delta Cut-Off

Machine eliminates expensive finishing

Cuts plastics, non-ferrous metals, etc. to exact length with polished smoothness; polishing and burring usually unnecessary. (Also convertible to abrasive cutting of steel.)

**DELTA - MILWAUKEE** . . *pioneers of small, compact dura*

# in high-production tooling

## Delta Machine Tools



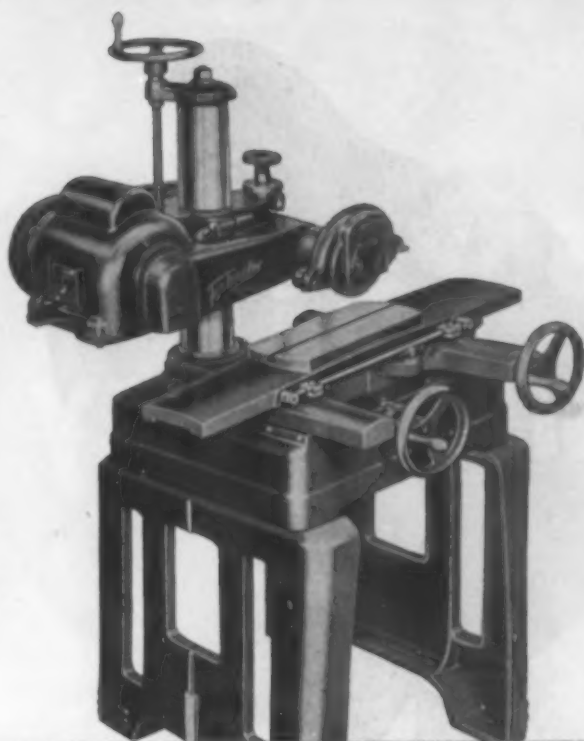
### Delta 14" Floor-Type Drill Press

Delta's patented construction provides both a self-aligning drive and a free-floating spindle. Many outstanding features, including smooth-working table-raising mechanism, built-in depth gauge, streamlined safety belt guard, quill with 5" stroke or travel, etc.

### Delta Toolmaker Surface Grinder gives dependable, trouble-free results

This husky, big-capacity grinder is a "heck of a lot of machine for the money," say delighted users. Ideal for surface grinding, tool sharpening, etc.

Designed for ease and speed of operation. Convenient controls... wide graduations on micrometer for close settings... unique wheel-adaptor that saves time on truing-up operations... many other features that assure you creditable performance. 7 x 1/2" wheel, 1 1/4" bore.



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gives you extra convenience, efficiency, safety.

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With the *Unlvis*, the first truly universal vise for grinding, drilling, and milling, this machine serves as a dependable, accurate Chip-Breaker Grinder for grinding the chip-breaker groove on carbide-tipped tools. Holds the tool at any conceivable angle — accurately reset at a moment's notice.

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M-9



## A New Name for a Very Old Yankee Manufacturer

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## Your Plastic Molder Can't Be Afraid of **MOLD-MAKING!**

**M**old-making is only one of the many integrated operations that produces your plastic part.

Only one—but it's a tough one. In the mold maker's hands your blueprint first takes form. In the right shape, a mirror-smooth mold with dimensions faithfully met within specified tolerances, is ready to produce precision parts under pressures up to ten tons per square inch through its lifetime. If it's wrong—we pull out a few gray hairs and start over. Your mold must be right, and we've got to know it.

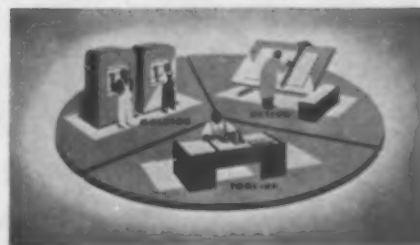
That's why we make our own molds here at Kurz-Kasch, and why mold-making experts gather at the Plastics Round Table with molders, designers, and engineers to plan them right. Only by pooling all the knowledge we've earned in growing up with the plastics industry can we tell you with

confidence, "We can take full responsibility for producing this job in a plant staffed and equipped to handle it from drawing board to your receiving platform."

We've found it better to say that, or say nothing. A Kurz-Kasch development engineer can tell you more.



**NOW'S THE TIME** to start planning future plastic applications. We're pretty busy already with Engineering on many jobs. Mold-making too, in some cases. Why not talk it over now with one of the largest exclusive molding plants in the country?



**KEEP PLUGGING WITH WAR BONDS . . . THEY'RE STILL PLUGGING OVER THERE**

# KURZ-KASCH

*For over 25 years Planners and Molders in Plastics*

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**FREE** Without obligation, ask us to send you this handy-reference Folder File. It includes a description of our plastics engineering and molding services, with examples of functional design.



# ENGINEERED PLASTICS

## from Design to Complete Assembly

Our specialty is the redesign of products and parts to permit maximum advantages from plastics, either as complete molded units or in combination with complementary metals.

In performing this service, we work closely with the engineering departments of manufacturers whose products require functional application of molded plastics.

With an experienced appreciation of the complementary values of plastics and metals, and complete facilities for designing, molding and assembling, we may be able to suggest improvements in your products.

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# TO GET SPEED + UNIFORMITY USE ELECTRONIC PREHEATING

## NEW METHOD REDUCES REJECTS, STEPS UP PRESS OUTPUT 50%

BY giving you both high speed and uniformity in preheating, electronic heat produces near-perfect plasticity of thermo-setting materials before molding. This high plasticity results from:

**Uniform Heating:** Electronic preheating softens the preform at the same rate all the way through. There are no hard lumps in the center nor "crusts" on the outside.

**Fast Heating:** With electronic heat, the temperature of the plastic material can be rapidly increased. Complete preheating from room temperature up to 275°F. and above can be attained in a matter of seconds (see Curve A). This rapid heating means freedom from premature curing.

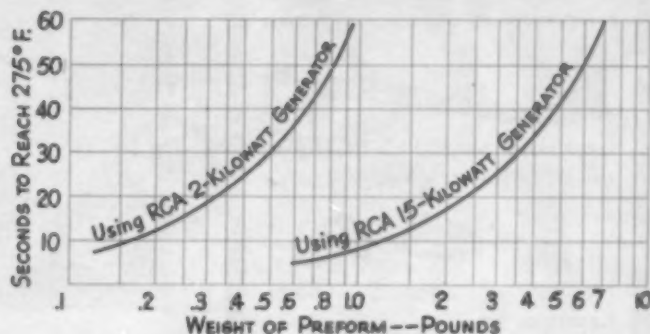
This Means that since electronic preheating combines fast heating with uniform heating, the entire preform mass is brought to ideal plasticity before it is placed in the mold. Such material easily flows into all parts of the mold cavity. Press closing is speeded up materially. Curing is quick and complete (see Curve B). Internal stresses which cause warping are eliminated. Mold pressures are reduced. Practically the only heat which must be supplied by the mold is that for curing; thus, curing time is greatly reduced.

**Net Results:** Electronic preheating has been definitely proved to increase product quality greatly; one molder recently reported a 75% reduction in rejects. Dimensional stability is improved by the elimination of residual stresses in the molded part.

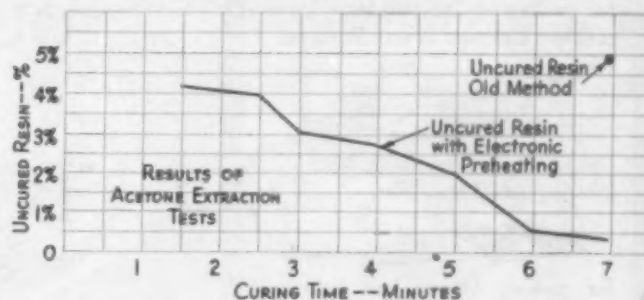
Press output can be increased, on the average, by 50%; two presses can do the work of three!

Because the entire preheating process is completed in less than a minute, the molding day can begin as soon as the mold is up to temperature.

Leading plastics authorities state that many previously "impossible" molding jobs can now be handled on standard presses.



● Curve A: Total preheating time for various weights of preformed material can be determined easily from these curves based on the standard RCA 2-kw and 15-kw electronic generators.



● Curve B: The uniformly high temperature obtained with electronic heat means that the mold must supply only curing heat; curve shows how curing time is shortened and quality maintained.

Mold damage is reduced because of the high plasticity obtained; thus, shutdowns due to broken molds are practically eliminated.

**Send Us Your Problem:** RCA electronic generators are now available for war work. RCA engineers have worked out a convenient data form to help you state your preheating problem. Send the coupon, or write details of your application to: RCA, Electronic Apparatus Section (70-35), Camden, N. J.



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In an undertaking of such magnitude, the importance of adhesives and starch products, for purposes such as those shown at the left, might easily be overlooked . . . but nothing escapes the Quartermaster Corps. It is this close attention to detail that has won for the Corps the implicit faith of its dependent millions.

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**SMALL ORDERS CAN BE FILLED  
WITHOUT WPB APPLICATION**

Effective April 6, Allocation Order M-25 has been revoked and Formaldehyde placed under General Allocation Order M-300 as in appendix A material subject to Schedule 9. The new order still permits purchases under "Small Order Exemption" of quantities up to 10,000 lb. of Formaldehyde, 3,000 lb. of Paraformaldehyde and 10,000 lb. of Hexamethylenetetramine in any calendar month. These quantities can be obtained without application. Quantities in excess of the above still require application on Form WPM-2945 (PD-600).





## 8 MILES UP—THE P-38 GETS FINGER-TIP CONTROL

No matter *how much speed* a fighter-pilot has *be must also have maneuverability*—be able to get in fast and get out quickly.

Now, even with the P-38's phenomenally increased speed, he can do just that. For Lockheed engineers, by installing aileron boosters actuated by the revolutionary Hycon "Stratopower" hydraulic pump, have given him "finger-tip control" over speed faster than sound. The application of these boosters, made practical for the first time, provides faster response of control surfaces, and as a result the Lockheed *Lightning* now outmaneuvers many single-engined ships—and fights higher than ever before in the thin air eight miles up.

To speed the day of Victory, we are using to the limit every facility at our command in the production of Hycon "Stratopower" pumps, and all of them are reserved for the planes of our armed forces.

LET'S ALL BACK THE ATTACK—BUY MORE WAR BONDS

### *And after the war—for peacetime*

Because of its compactness and phenomenally high pressure, furnishing *variable volume up to 3000 pounds per square inch*, the Hycon "Stratopower" pump will do a great many hydraulic jobs *better*.

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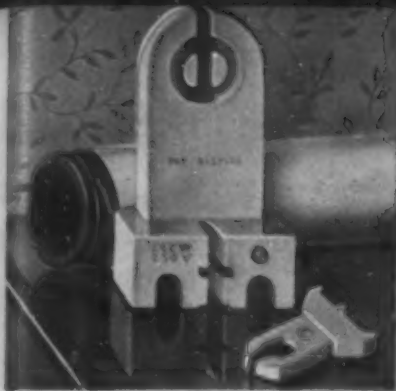
*Stratopower Pump*

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**GOOD ELECTRICAL PROPERTIES** and phenomenal impact strength make Acetate an ideal housing for portable radios.



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For three reasons, the Cellulose plastics are being used increasingly in electrical applications. Being non-conductors, they provide good insulation. They have excellent "dielectric strength"—which is to say they resist the impact of electrical voltages and prevent their rupturing the plastic barrier. And they are exceptionally non-corrosive, even in contact with current-carrying copper wire, in the presence of moisture.

In the Cellulose compounds you will find the electrical properties for *your* product. We do *not* ourselves make plastics, but as a leading producer of Cellulose compounds we have developed each of the properties which give the Cellulose plastics their unique combination of advantages. We have literature and data, based on our years of research, which we will gladly send you. Please address your letter to Cellulose Products, Department MP-54, Hercules Powder Company, Wilmington 99, Del.

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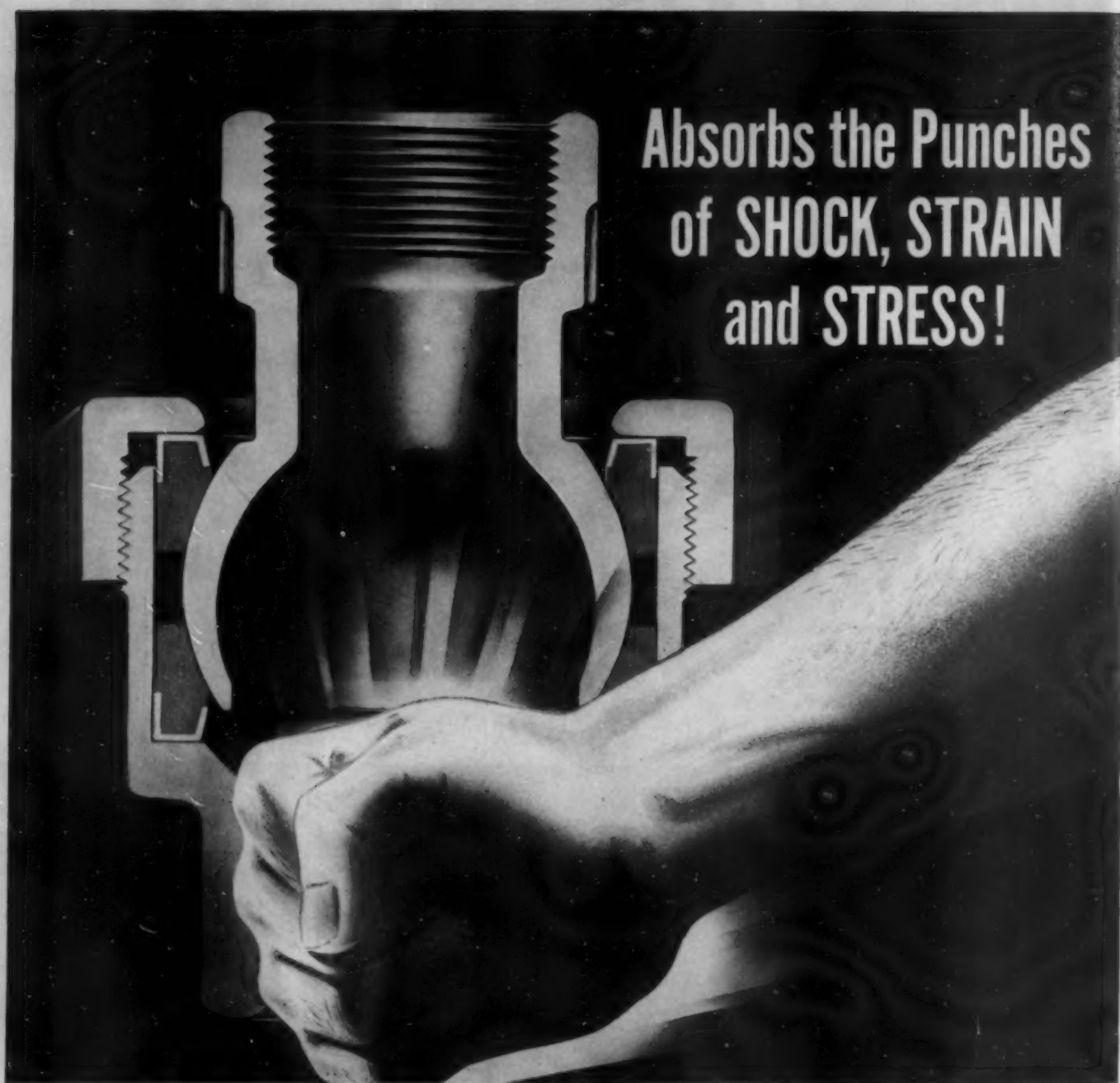
**THIS ELECTRICAL INSTRUMENT**, used by industry and the armed forces for testing open circuits, locating grounded fixtures and blown out fuses, is made of non-conducting, electrically resistant, transparent Cellulose Acetate. Made for Star Case Co. by Sterling Plastics, from Lumarith, Celanese Celluloid Corp.

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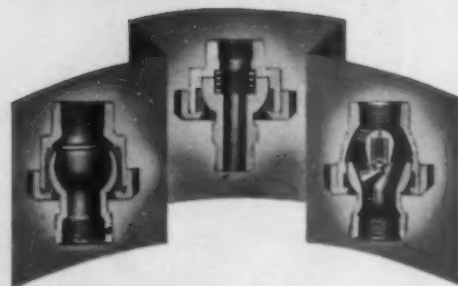
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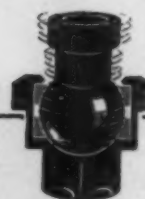
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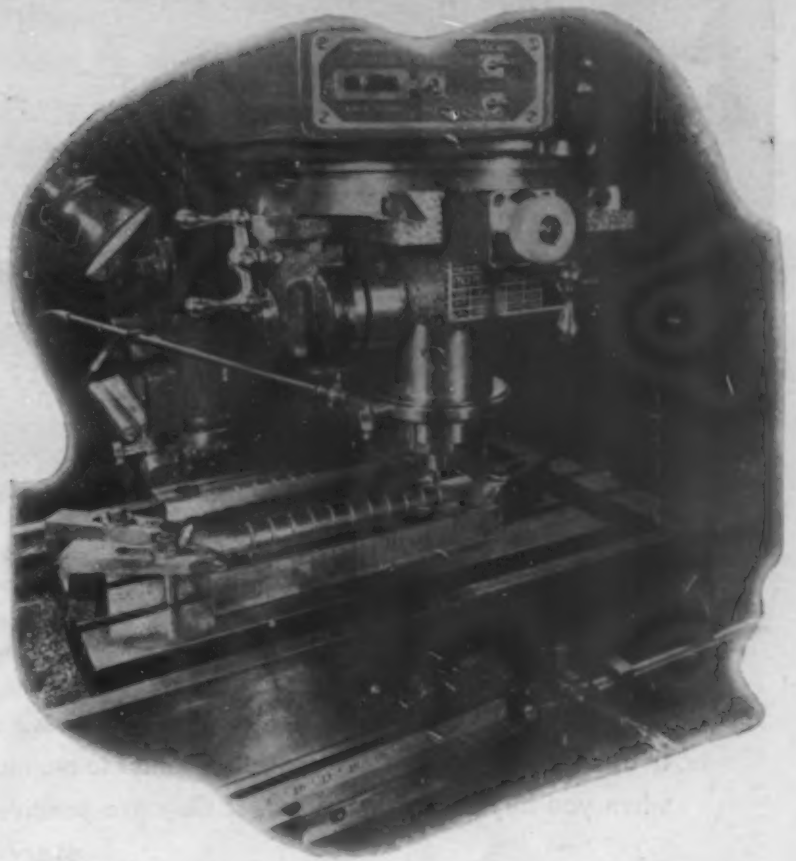
EVERY



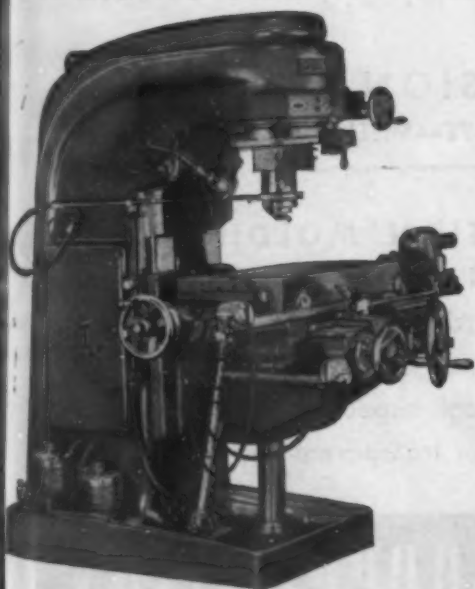
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# ROTARY HEAD MILLER . . . PLUS CHERRYING ATTACHMENT . . . SIMPLIFIES THIS "TRICKY" MILLING OPERATION

The Milwaukee Rotary Head Miller equipped with a cherrying attachment made "short work" of the "tricky" milling required on this injection mold. It took just two hours to complete the job — far less time than by any other method known.



The cherrying attachment is an auxiliary rotary head, mounted at 90° to the head of the miller. It is used to mill circles and angles in a vertical plane. When used with rotary head motion, spherical and conical cavities can be accurately and rapidly milled — in almost all cases difficult operations become a comparatively simple task.



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*Write for Bulletin No. 1002C for complete information on the Milwaukee Rotary-Head Miller and the accurate and rapid production of all types of molds and dies.*

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For post-war plastics think of Bridgeport.



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Courtesy of Hill-Shaw Co.



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The melamine upper bowl of Hill-Shaw's Vaculator for the Navy opens new possibilities for plastics applications in the post-war home. Molded by Watertown, it is the same composition as the stain and boiling water resistant Watertown Ware cups and saucers, designed for our armed forces.

It is practically unbreakable, does not chip or scar easily and is odorless and non-porous.

Watertown was selected as molder because of their familiarity with melamine compounds and their engineering skill in making molds economically. Their large presses, with a 36 inch stroke, amply accommodate dies to mold a tall shape such as this 12 inch high bowl.

If you require a plastic shape that is difficult or unusual in design, let our engineers help you with your problems. The Watertown Manufacturing Company, 1000 Echo Lake Road, Watertown, Connecticut. Branch offices in New York, Chicago, Cleveland and Detroit.

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# The aerial camera man, too, aims accurately ... *through* Plexiglas



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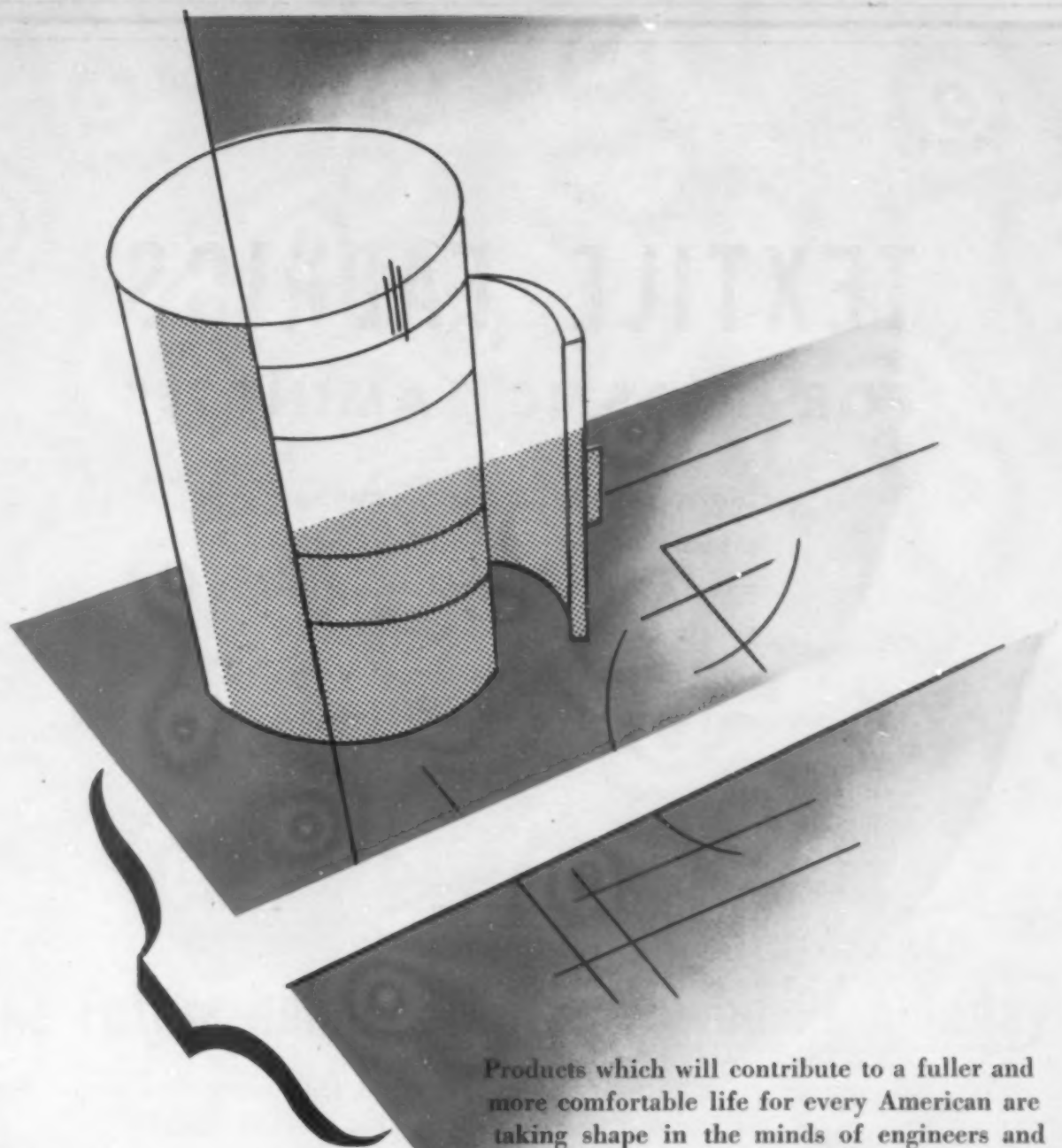
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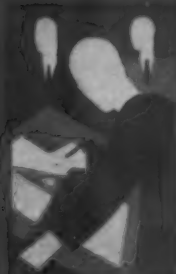


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CHICAGO  
549 W. RANDOLPH ST.

## SERVICE—WITH A LONG REACH

Make a note of Consolidated's conveniently spotted branch service centers . . . And as plastics production problems confront you, contact the office nearest to you. These home-backed branches are staffed by plastics technicians with a special know-how for starting things right and for getting them done the same way!

# Consolidated

MOLDED PRODUCTS *Corporation*

309 CHERRY STREET, SCRANTON 2, PA.



## LIGHT but **TOUGH!**

**CHEMACO CELLULOSE ACETATE** is light, tough, resilient—able to withstand impact. It is available now for all war uses and most essential civilian applications in water-clear crystal, translucent and opaque materials in a wide range of colors. Parts molded from Chemaco Cellulose Acetate are outstanding for fine, lustrous surfaces, brilliant color or crystal clarity, warmth and pleasant feel to the touch, stability and lightness.

Molding compounds are available for extrusion, compression and injection molding and are adaptable to varied specifications. Consult our engineers when you are specifying plastics. They can help you determine the correct material and formula. Chemaco Corporation, subsidiary of Manufacturers Chemical Corporation, Berkeley Heights, N. J. Manufacturers of Cellulose Acetate, Ethyl Cellulose, Polystyrene and Vinyl Compounds. Branch offices in Cleveland, Los Angeles, San Francisco, Montreal and Toronto.

**Chemaco**

**Plastics to Mold the Future**

**IN WAR...**

**AND PEACE!**



**PROBLEM:**

**BOWL**



Must have lustrous finish and wide range of permanent colors, both impervious to rough handling, heat and liquids.



**PISTOL GRIPS**

Expansion co-efficient must be suitable for close tolerance with metal. Usefulness must not be impaired by heavy blows, moisture, or oil.

**SOLUTION:**

**KYS-ITE**

—the long-fibred wood pulp-filled synthetic resin plastic, preformed before curing.

Versatile is one word for Kysite. Successful is another. This remarkable thermo-setting plastic is doing a real job for essential industries today, and its performance has earned Kysite its place on today's specification sheets for tomorrow's products. Here are some of the reasons.

**SHAPES** for Kysite forms can be simple or intricate; can incorporate permanent metal inserts. Preforming before curing insures dimensional stability and saves production, machining, finishing and assembly operations.

**PRACTICAL** and varied in application because of its dielectric and non-reverberating properties, impact strength (4 to 5 times greater than ordinary plastics), effectiveness under wide temperature variations, and resilient strength.

**ATTRACTIVE** and light in weight Kysite comes in many rich, beautiful colors and lustrous finish; is unaffected by boiling water, mild acid solutions, grease and alcohol.

**KEYES**  
**MOLDED PRODUCTS**

We will again be able to custom mold to your specifications as completed war contracts release our manufacturing facilities. The wait may not be long, and production is being scheduled as orders are placed. May we suggest you contact us promptly?

Buy War Bonds—and Keep Them

**KEYES FIBRE COMPANY**

420 Lexington Avenue

New York 17, N. Y.

Plant at Waterville, Maine

# GEARED • for production

OF  
MOLDED  
PLASTICS

## *Vital Services to Customers Make Reynolds Pre-eminent in Molded Plastics*

Plastic molding, at Reynolds, means resourcefulness . . . intelligent ingenuity . . . expert craftsmen . . . and the determination to protect the interest of Reynolds customers . . . all with a deep appreciation of the problems of the other fellow.

Reynolds service will take you all the way through designs, molds and complete finish.

Plastics fabrication by compression, injection, extrusion, sheet forming.

INVEST IN WAR BONDS

# REYNOLDS

## MOLDED PLASTICS

C A M B R I D G E , O H I O

DIVISION OF REYNOLDS SPRING CO., JACKSON, MICH.



ENGINEERING  
ABILITY

PRODUCTION  
ABILITY

SERVICE  
ABILITY

SOUND COMPANY  
POLICY

STRONG FINANCIAL  
STRUCTURE

22 YEARS  
OF EXPERIENCE

FOOT  
head  
Nation  
tough  
the w  
strong

Vul-C  
Vulcan  
institu  
tee, m  
and sh  
for Inc

TRU  
made  
provid  
and d  
luggag  
use. L

n  
OF  
ED  
CS



## These new ration tokens... *what are they made of?*



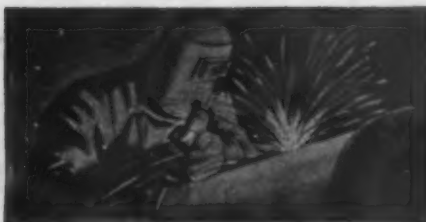
They're made of something that you may never have seen before, but to men in the electrical and other important industries, this remarkable material has been well known for over 70 years.

But to tell you simply what it is... we take cellulose, treat it chemically to change its structure, then we remove the chemicals by a long puring process. The resultant product—National Vulcanized Fibre.

That's what your tokens that cut-down shopping time are made of—that's what thousands of products you see or use every day depend upon. A few are pictured below.



**FOOTBALL PLAYERS** are protected with head gear and other guards made of National Vulcanized Fibre—it combines toughness with lightness in weight—half the weight of aluminum. One of the strongest materials per unit weight, known.



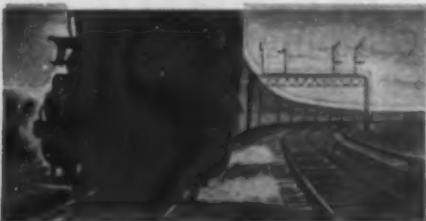
**WELDERS** use shields made of National Vulcanized Fibre for it can be molded into just the right shape. Its light-weight, resilient, non-denting, and durable qualities make it practical, economical and long-lasting for this industrial use.



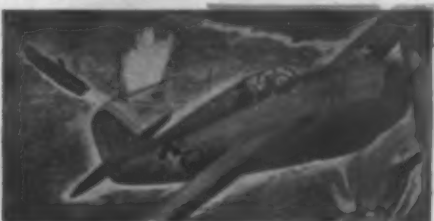
**HELMETS** that protect workers in mines, shipyards and hazardous industrial jobs are made of National Vulcanized Fibre. It helps prevent injuries—has remarkable property of absorbing impact blows and distributing their forces.



**Vul-Cot WASTE BASKETS** of National Vulcanized Fibre have wide use in offices, institutions, homes. Carry a 5 year guarantee, made in wide range of attractive colors and shapes; won't splinter or corrode. Look for Indian Head Trade Mark.



**RAILROADS**—In automatic block signal systems, the only electrical insulating material yet found to possess the required durability and resistance to deformation, is National Vulcanized Fibre. It insures dependable operation of signal systems.



**AIRPLANES**—In planes, countless parts are fabricated from National Vulcanized Fibre for it combines high dielectric and mechanical strength, shock and wear-resisting properties. A well-known use is the collar in the famous self-locking nut.



**TRUNKS and LUGGAGE** of quality are made of National Vulcanized Fibre. It provides lightness in weight, great strength and durability. Its tough resiliency gives luggage the ability to withstand hardest use. Look for Indian Head Trade Mark.



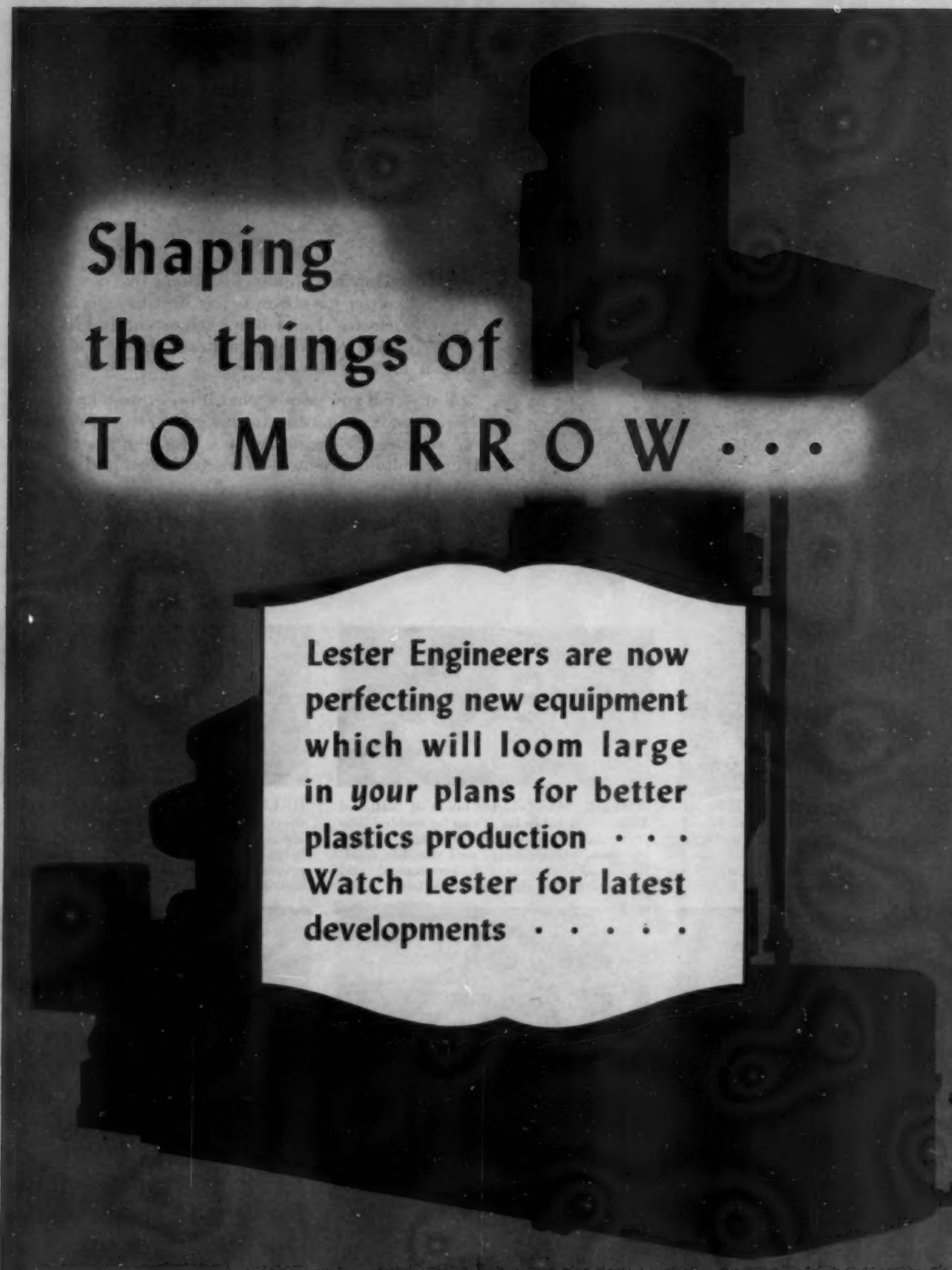
**Your SHOES**—Yes, even there, the chances are you will find National Vulcanized Fibre. It is used in women's shoes as a heel seat reinforcement, because it provides a strong base, a tighter seat and prevents the heels from pulling off.

### MANUFACTURERS! DESIGNERS! ENGINEERS!



Send for a Free Copy of our eight-page folder which suggests practical and economical uses to which you can put this versatile material possessing such an unusual combination of physical, electrical and mechanical properties. Please write on your company letterhead.

**NATIONAL VULCANIZED FIBRE CO.**  
Wilmington 99, Delaware



Shaping  
the things of  
**T O M O R R O W . . .**

Lester Engineers are now  
perfecting new equipment  
which will loom large  
in your plans for better  
plastics production . . .  
Watch Lester for latest  
developments . . . . .

National Distributors:  
**LESTER-PHOENIX  
INC.**

3711 CHURCH AVENUE  
CLEVELAND, OHIO

**LESTER**  
INJECTION MOLDING MACHINES

*Representatives in*  
NEW YORK CITY • DETROIT  
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CINCINNATI

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DOWDING & DOLL, LTD.,  
LONDON, ENGLAND  
SCOTT & HOLLADAY PTY. LTD.  
SYDNEY, AUSTRALIA  
& WELLINGTON, N. Z.

*"Transposter"*  
**PLASTIC DISPLAYS**  
*for*  
*My Lady's Shoes*  
*and Hosiery*



# *Attractively Finished* WITH THE HELP OF **LEA** METHODS *and* MATERIALS

This isn't war work, as so much in plastics and metals is today. But it does involve the production of articles needed to help maintain, so far as possible, our normal business contacts, one of which is to display available merchandise attractively. These Shoe and Hosiery Stands, made of LUCITE or PLEXIGLAS by Transposter Service of Boston, contribute their share.

But note how dainty and delicate they are. It takes real skill, the proper methods and proper materials

to finish these stands without damaging them. LEA Finishing Specialists helped to devise proper finishing methods and are providing the materials as needed.

This finishing service to Transposter is typical of what LEA can do and is doing for the plastic industry as a whole. Perhaps you have a finishing problem that is bothering you.

Why not call in a LEA specialist?



## THE **LEA** MANUFACTURING CO.

**Waterbury 86, Conn.**

*Burring, Buffing and Polishing . . . Manufacturers and Specialists in the  
 Development of Production Methods and Compositions*

14½" SOUTH BEND  
TOOLROOM LATHE



SPECIFICATIONS	
Swing over bed . . . . .	14½"
Hole through spindle . . . . .	1½"
Maximum collet capacity . . . . .	¾"
Thread cutting feeds (48) . . . . .	4 to 224 per inch
Spindle speeds . . . . .	8
Power longitudinal and cross feeds . . . . .	48

# SOUTH BEND TOOLROOM LATHES

*for Precision Machine Work*



## TRAINING HELPS

Sound films, books, wall charts, and bulletins are available for training lathe operators. Write for a copy of Bulletin 21-C.

Skilled craftsmanship combined with excellent design in South Bend Toolroom Lathes make them highly efficient for machining work to precision limits.

Their accuracy, speed, and smooth power assure fine finishes. Wide ranges of turning and facing power feeds, thread cutting feeds, and spindle speeds, plus ease of operation, help to simplify the exacting jobs.

South Bend Toolroom Lathes and Engine Lathes are made with 9", 10", 13", 14½", and 16" swings. South Bend Precision Turret Lathes are made with 9" and 10" swings. Write for a copy of Catalog 100-C.



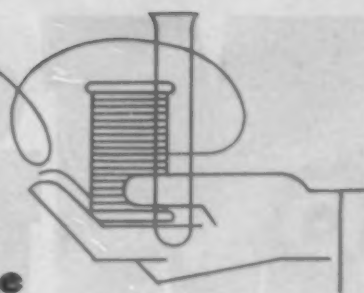
**SOUTH BEND LATHE WORKS**  
SOUTH BEND 22, INDIANA      LATHE BUILDERS FOR 37 YEARS

interior of

**VELON**\*

every color practical

everything durable



"Interior of *Velon*" will be a feature of postwar homes, offices, institutions—as well as for trains, planes, buses, cars.

It will mean an endless variety of colors—practical in even the most delicate shades—for upholstery and seating, for draperies, curtains, paneling, window screens, and for any kind of colorful trim.

It will mean not only new beauty—but a new durability, too! For *Velon*, in every form, has a unique ability to "take it" day after day, year after year, and always look new.

It can be wiped sparkling clean and dry in a few seconds, with water or with cleaning fluid. And *Velon* is highly resistant to fire, grease, acids, alkalies, solvents—is virtually indestructible.

Keep your eye on *Velon*. It will be a key word in your basic English!

P. S. For completely modern seats, make the cushioning *Foamex*.

**Firestone**

ANOTHER CONTRIBUTION TO A BETTER WAY OF LIFE by

\*TRADE MARK • PRONOUNCED VEL-LÓN

MAY • 1944

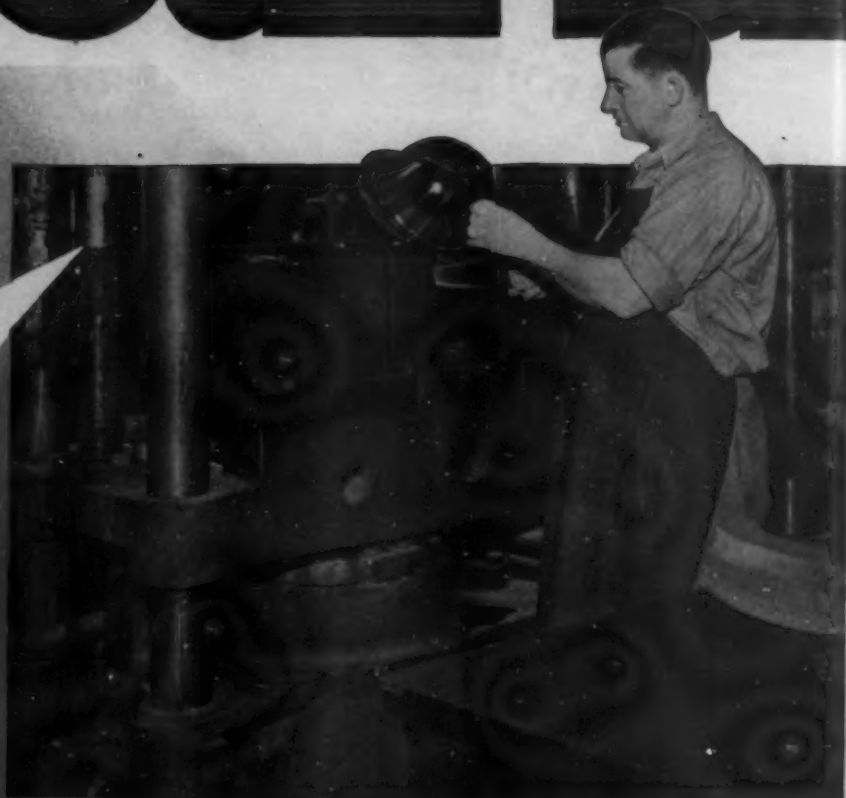
45

# Micarta

**MICARTA**  
meets problems  
like these and  
hundreds more



**SMOOTH BEARINGS FOR ROUGH CROSSINGS.** Destroyers, destroyer escort vessels, LCI ships and many other U. S. Navy and Maritime vessels depend on Micarta stern tube bearings. Micarta cushions shocks of heavy seas, multiplies bearing life as much as 400 per cent, is unharmed by constant immersion in salt water.



**MILLIONS OF MICARTA HELMETS** have been produced for the protection of our Armed Forces. This wartime application demonstrates the deep-draw possibilities of this industrial plastic, as well as its great impact strength.

**CONTROL PULLEYS FOR PLANES** have been made of Micarta for over a quarter of a century. They extend the life of both pulley and cable.



# the No. 1 example of

## LAMINATED INDUSTRIAL PLASTICS AT WORK

What are the *practical* facts about new uses for industrial plastics? Where have war uses actually proved plastics to be permanent and better replacement materials—not substitutes, nor “materials of the future?”

MICARTA provides authoritative, factual answers to these questions. MICARTA has countless uses yet unknown—but tangible facts about its performance in almost any use can be found in current, existing applications. MICARTA is the number one example of industrial plastics *at work* . . . the product of the largest laminators of industrial plastics—Westinghouse.

The uses of MICARTA shown here are but a few of thousands. Performance data on many, such as MICARTA aircraft applications, dates from as long ago as 1917. The length and breadth of this experience in the practical application of plastics provide an unequalled fund of facts to guide designers and engineers.

Essential facts about MICARTA are contained in the new MICARTA Data Book B-3184-A. Ask for your copy. Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa., Dept. 7-N.

J-06348

**GEARS** made of Micarta absorb vibrations, resist wear, and cushion repeated shocks without deterioration.



**BOMB RACKS** to hold bombs under a plane's wings have been successfully molded of Micarta. They furnish an excellent example of Micarta's great strength and adaptability to intricate molded shapes.

**AIRCRAFT FAIRINGS** formed from flat sheets provide needed strength with less weight than aluminum.

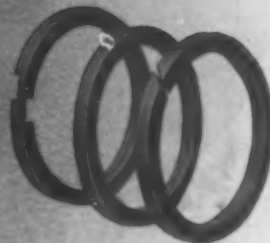


**AIRCRAFT PARTS** like guides, spacers, brackets are made of Micarta because of lightness, high strength and resistance to wear and corrosion.



MICARTA “444” is the new thin sheet Micarta that can be quickly, easily formed into intricate shapes with inexpensive wooden dies. Now used in many aircraft applications.

**PUMP RINGS** made of Micarta do not soften in service, wear slowly, and will not score cylinder walls.



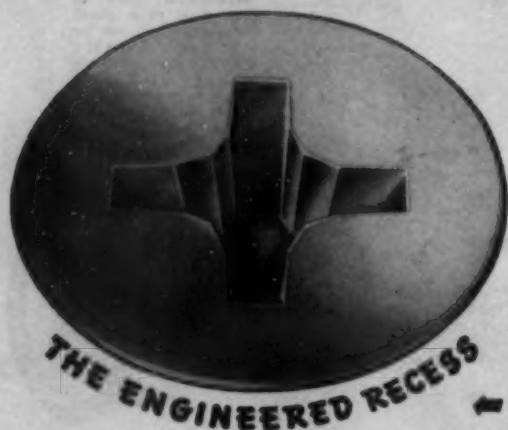
**STEEL MILL ROLL NECK BEARINGS** save 25 to 50% power cost . . . last 20 to 40 times longer . . . permit more accurate holding of gauge.



**INSULATION PROBLEMS** of all types have been solved with Micarta—a  $\frac{1}{8}$ " thick piece withstands 62,000 volts!



**BLONDE? MAYBE--SMART? COULD BE!**  
**MUSCLE? NOT MUCH-->>>>>> BUT,**  
**BROTHER, SHE'LL DO A WHALE OF A JOB**  
**ON YOUR ASSEMBLY LINE IF YOU**  
**USE THE RECESSED HEAD SCREW**  
**THAT MAKES SCREW DRIVING TROUBLE-**  
**PROOF--THAT ENDS**  
**THE NEED FOR SKILL**  
**AND BRAVN**  
**IT'S PHILLIPS**



#### Anyone can drive Phillips Screws!

Time was when it took real "hemen" to drive screws. They had to be strong... had to have skilled hands... had to be trained. But today the job's a cinch for anyone!

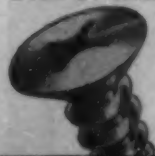
What makes it a cinch is the Phillips Recessed Head Screw—the screw which, time studies prove, steps up screw driving speed as much as 50 per cent.

With Phillips Recessed Head Screws, there's no premium on brawn! They drive easy—because turning power is fully utilized. Nor is there any premium on

training or skill. Dangerous driver skids are out, and workers just can't fumble, make wobbly starts, or drive slantwise.

As a result, untrained girls quickly match anything experienced male operators do—driving Phillips Screws.

Think what this means to you in (1) man-and-training hours saved, in (2) increased production, in (3) finer workmanship. Then ask yourself if you're getting the same advantages from slotted head screws... or from any other type you're using.



# PHILLIPS *Recessed Head* SCREWS

WOOD SCREWS · MACHINE SCREWS · SELF-TAPPING SCREWS · STOVE BOLTS

#### TO MAKE WARTIME QUOTAS AND PEACETIME PROFITS

**Faster Starting:** Driver point automatically centers in the Phillips Recess... fits snugly. Fumbling, wobbly starts, slant driving are eliminated. Work is made trouble-proof for green hands.

**Faster Driving:** Spiral and power driving are made practical. Driver won't slip from recess to spoil material or injure worker. (Average time saving is 50%.)

**Easier Driving:** Turning power is fully utilized. Workers maintain speed without tiring.

**Better Fastening:** Screws are set-up uniformly tight, without burring or breaking of screw heads. The job is stronger, and the ornamental recess adds to appearance.



IDENTIFY IT



Center corners Phillips Recess rounded... NOT square.



Bottom of Phillips Recess is near flat... NOT tapered to sharp point.

**23 SOURCES**

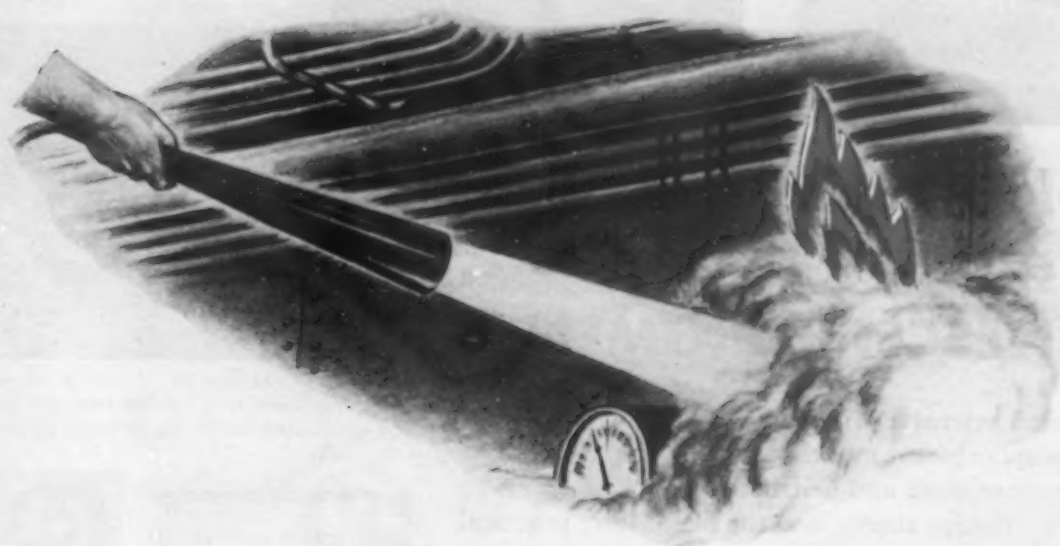
American Screw Co., Providence, R. I.  
 Atlantic Screw Works, Hartford, Conn.  
 The Bristol Co., Waterbury, Conn.  
 Central Screw Co., Chicago, Ill.  
 Chandler Products Corp., Cleveland, Ohio  
 Continental Screw Co., New Bedford, Mass.  
 The Corbin Screw Corp., New Britain, Conn.  
 General Screw Mfg. Co., Chicago, Ill.

The H. M. Harper Co., Chicago, Ill.  
 International Screw Co., Detroit, Mich.  
 The Lamson & Sessions Co., Cleveland, Ohio  
 Manufacturers Screw Production, Chicago, Ill.  
 Milford Rivet and Machine Co., Milford, Conn.  
 The National Screw & Mfg. Co., Cleveland, Ohio  
 New England Screw Co., Keene, N. H.  
 Parker-Kalco Corp., New York, N. Y.

Pawtucket Screw Co., Pawtucket, R. I.  
 Phoenix Manufacturing Co., Chicago, Ill.  
 Reading Screw Co., Norristown, Pa.  
 Russell & Ward Bolt & Nut Co., Port Chester, N. Y.  
 Seavill Manufacturing Co., Waterville, Conn.  
 Shakerproof Inc., Chicago, Ill.  
 The Southington Hardware Mfg. Co., Southington, Conn.

# Vynylite

TRADE MARK



## Flame Resistance **AN IMPORTANT INSULATION REQUIREMENT FOR YOU?**

Non-flammable wire and cable insulation may not be as vital on your installations as on a warship. But the insulation that has demonstrated this property in battle, and has come through, despite flame, corrosive brine, oil and grease, may be worth your careful consideration.

VINYLITE plastic wire and cable insulation will not support combustion. It is non-oxidizing, and highly resistant to abrasion. It is also resistant to acids, alkalis, oils, greases, and common solvents. It can be made in a wide variety of colors.

What do these properties mean to you? Insulation

safety in railway, marine, automotive, and general industrial wiring? More dependable insulation for power and lighting circuits? Oil and water-resistant portable cords? Easier identification of circuits? Write Department 7 for technical information on the properties, advantages, and broad range of usefulness of wire and cable insulated with VINYLITE plastics.

*Plastics Division*

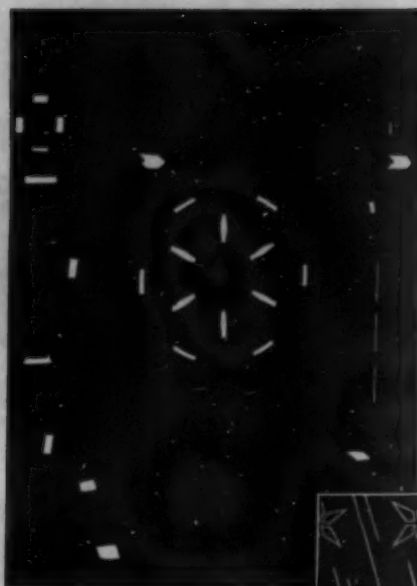
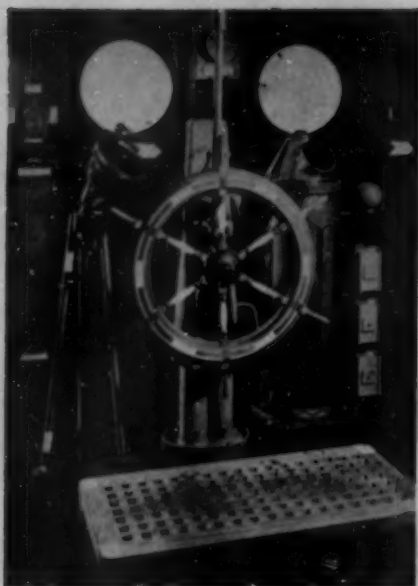
**CARBIDE AND CARBON CHEMICALS CORPORATION**

*Unit of Union Carbide and Carbon Corporation*



30 EAST 42ND STREET NEW YORK 17, N. Y.

# Plastics



**PHOSPHORESCENT MARKING TAPE** is used extensively aboard ship, applied as directional indicators to the walls of passageways, exits, messhalls, officers' and crews' quarters and engine rooms, and to mark and identify obstructions, fire-fighting stations, and other vital equipment. After activation by the ship's lighting, the tape "glows" in the dark, permitting movement aboard ship, and evacuation in the darkness in any emergency.

The photographs at the left show (extreme left) steering equipment marked with phosphorescent tape and (immediate left) how this tape "glows" in the dark.

## Developed for War... Projected for Peace LUMINESCENT PIGMENTS

have been used extensively in a wide variety of war applications—phosphorescent marking tapes, signs, fluorescent maps, instrument dials and instruction plates, computers and charts, correction sheets, and the like. Many practical post-war applications are indicated, a few of which are illustrated on this page.

These pigments are no longer novelties at \$30 per lb., but commercial products at down-to-earth prices of from 90c to \$2.50 per lb., available in 16 grades and color types, for use in:

- *Paints and Lacquers*
- *Coated and Filled Paper*
- *Coated and Printed Textiles*
- *Plastics*
- *Printing Inks*
- *Decalcomanias*

Our new booklet "The ABC of Luminescence" should suggest many ways in which these pigments can be used in your products of tomorrow. Your copy will be mailed to you on request.

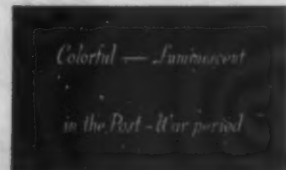


**PHOSPHORESCENT TRADE-MARKS**, or name plates on your products "glow" in the dark, leaving a lasting impression on consumers' minds.

**PHOSPHORESCENT SIGNS** (plastic, painted, printed) give directional or instructional guidance in the dark in the event of power failure or emergency. Photographs: (1 & 3) taken in white light, and (2 & 4), photographed in the dark.



**LUMINESCENT TEXTILES** in the form of draperies, lamp shades, etc. may help to decorate the post-war theatre, hotel room, cocktail lounge or home to permit movement in the dark.



**THE POST-WAR BILLBOARDS**, posters and displays may carry one message in daylight, a different luminescent one at night, or luminescent on-and-off flash effects in the dark.



**COLORFUL, LUMINESCENT EFFECTS** (painted, printed, plastic) for interior decoration in semi-darkness, as illustrated above (left) in daylight, and (right) taken in the dark.



DEVELOPMENT PRODUCTS DIVISION

**THE NEW JERSEY ZINC COMPANY**  
160 FRONT STREET • NEW YORK 7, N. Y.

Chicago • Boston • Cleveland • San Francisco

# Memo for Tomorrow



DEVOTED to the cause of Victory today, Timken Tapered Roller Bearings again will be available for all requirements — in unlimited quantities — when the time comes to "beat the swords into plowshares".

In the meantime, keep in mind the advantages listed at the right — all combined in the Timken Bearing.

THE TIMKEN ROLLER BEARING COMPANY, CANTON 6, OHIO

**TIMKEN**  
TRADE MARK REG. U. S. PAT. OFF.  
**TAPERED ROLLER BEARINGS**

## MEMO HIGH LOAD CAPACITY

Any desired combination of radial and thrust loads.

## MEMO SELECTIVITY

Over 3,000 sizes and types to choose from.

## MEMO ADJUSTABILITY

To any preload.

## MEMO PRECISION

To the necessary degree for any application.

## MEMO FIELD ENGINEERING SERVICE

Available from strategically located district offices.

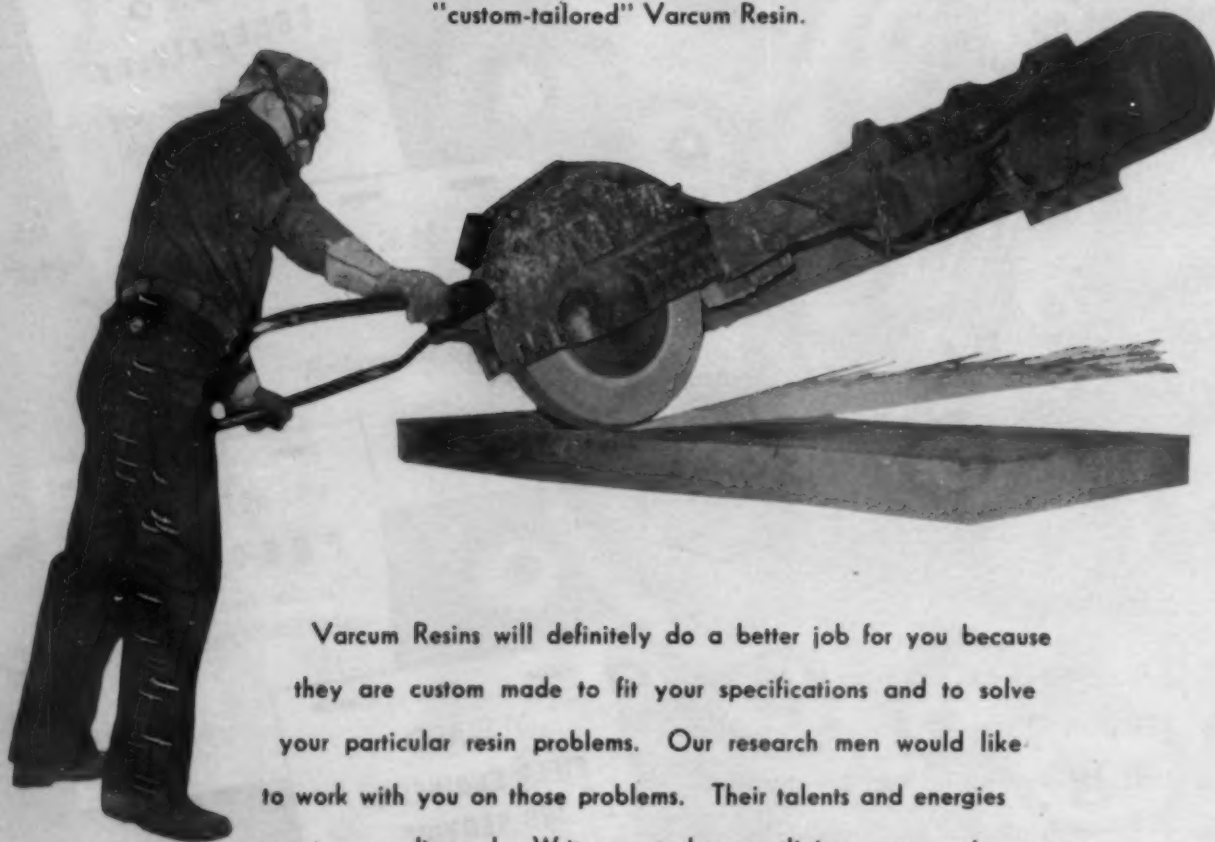
## MEMO SALABILITY

Timken Bearing Equipped machines preferred and demanded by users everywhere.

**VARCUM RESINS GIVE  
GRINDING WHEELS  
THEIR** *Guts*

On no job, anywhere, is phenolic resin called upon to give a rougher, tougher performance than in America's war-weary\* grinding wheels. Varcum Resins are high on the favorite supply lists of the country's finest manufacturers of abrasive

wheels. There's a reason for this preference and it's one with which you'll heartily agree . . . once you've worked with a "custom-tailored" Varcum Resin.



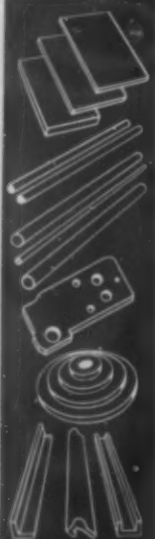
Varcum Resins will definitely do a better job for you because they are custom made to fit your specifications and to solve your particular resin problems. Our research men would like to work with you on those problems. Their talents and energies are at your disposal. Write us today, outlining your resin problems, and let us present you with a practical solution. Naturally, there is no obligation on your part and we're sure you'll be more than pleased with the result.

**VARCUM**  
CHEMICAL CORPORATION  
NIAGARA FALLS, NEW YORK

CUSTOM-MADE RESINS FOR THE WORLD'S FINEST PRODUCTS



## When Watt asked Why, Steam went to Work



SHEETS

RODS

TUBES

FABRICATED  
PARTS

MOLDED-MACERATED  
and  
MOLDED-LAMINATED  
FORMS and PRODUCTS

**S**TEAM jiggled the lid of many a kettle before James Watt asked why . . . and went on to make steam work an engine that helped touch off the Industrial Revolution.

Plastics provide similar opportunities for investigation.

Possibly you haven't used plastics for as many applications as you profitably might. Perhaps you haven't looked into plastics at all . . . but

should. So, a suggestion: If you, with your first-hand knowledge of the properties you need in a material, will tell us what your physical, chemical, electrical, or mechanical requirements are, we will quickly see whether our type of technical plastics can help you in any of your current or future applications. Write for the complete Synthane catalog. Synthane Corporation, Oaks, Penna.

SHEETS · RODS · TUBES · FABRICATED PARTS  
MOLDED-LAMINATED · MOLDED-MACERATED

# SYNTHANE

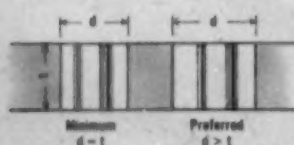
*Plan your present and future products with Synthane Technical Plastics*

# SUGGESTIONS ON DESIGN FOR THE USE OF SYNTHANE

Synthane technical plastics are easy to machine by usual shop methods. However, the work of the production department can be simplified and costs and spoilage reduced by following these suggestions when designing parts:

**PUNCHED OR SHAVED EDGES**—Punching produces a relatively smooth edge in thicknesses up to 1/16 in. For extra smoothness, especially in thicknesses over 1/16 in., shaving should be specified.

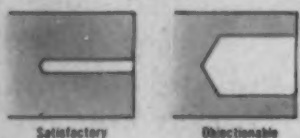
**PUNCHED vs. DRILLED HOLES**—Tolerance can be held closer on drilled holes than on punched holes but rarely is the accuracy of a drilled hole necessary if the hole can be punched.



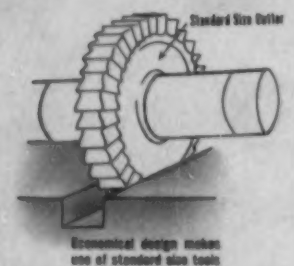
**DIAMETER OF PUNCHED HOLES**—The preferred ratio of hole diameter to thickness of material is not less than 1:1. That is, the diameter of a punched hole should not be less than thickness of sheet.



**DISTANCE BETWEEN PUNCHED HOLES**  
—PUNCHED HOLES NEAR EDGES  
—The distance between the circumferences of punched holes or between the circumference of a punched hole and the edge of a piece should not be less than 1-1/2 times the thickness of the piece.



**HOLES PARALLEL TO LAMINATIONS**—Avoid large holes parallel to laminations where subsequent pressure, as from a screw, might injure the piece.

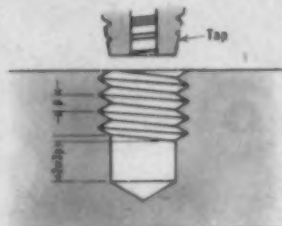


**DESIGN FOR MACHINING WITH STANDARD TOOLS**—Try to design parts so that machining can be done with standard tools or cutters. Specify standard size holes and slots wherever possible to avoid special tooling.

**TOLERANCES**—Give careful consideration to tolerances. It is poor economy to specify closer tolerances than are actually needed. As a matter of fact, laminated plastics cannot be held to tolerances such as .000"—.0005". The minimum tolerance advisable on dimensions

under 1/2 in. is a total of .002". This tolerance is the absolute minimum and all parts should be designed with greater tolerances if possible.

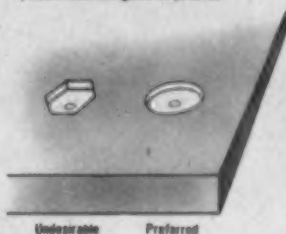
**TAPPING TOLERANCES**—Tapping should not be specified closer than a Class 2 fit with 65 to 70% of thread. Additional thread depth would add very little strength at the risk of breaking threads.



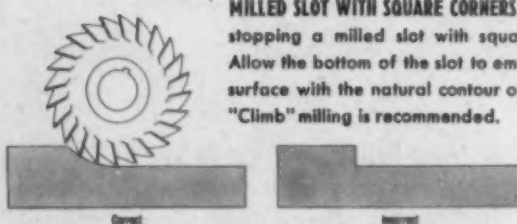
**TAPPING IN A BLIND HOLE**—When tapping in a blind hole, allow a depth of several threads from the bottom of the hole to first full thread for clearance.



**AVOID IRREGULARLY SHAPED HOLES**—Eliminate, wherever possible, irregularly shaped holes unless the thickness of the piece permits punching. Irregularly shaped holes on thicker sections can be made, but special tools are required.



**IRREGULAR COUNTER BORES AND RECESSES**—Eliminate entirely all irregular counter bores and recesses (except for round).



**MARKING PARTS**—Most parts can be marked with a punch, engraved or printed by the Synthographic process. The thinnest of materials can be printed.

**FORCED FITS**—The close tolerances required for forced fits in metal are not at all necessary in Synthane. Males can be as much as .005" oversize.

## SYNTHANE

SYNTHANE CORPORATION, OAKS, PENNA.  
REPRESENTATIVES IN ALL PRINCIPAL CITIES

# PLASTIC LAMINATES

*A few current applications of*

## RIEGEL-X PAPERS

THE ACCEPTED STANDARD  
FOR PAPER BASE  
LAMINATED PAPERS



Start thinking now  
how Riegel-X Papers  
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105

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# RIEGEL-X

X A group of plain and impregnated base papers for X  
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## call it "Know How"...

There are many names for skill and experience but no substitute for the combination. Through 15 years of peacetime production, Allied Products Corporation perfected the skill of its craftsmen and the facilities of its four great plants.

Now our many skills are turned to producing the tools and dies and parts needed for war. We are proud that each of our four plants flies the Army-Navy "E" for excellence of production.

### ALLIED PRODUCTS CORPORATION

Detroit and Hillsdale, Michigan

Precision Aircraft Parts ... Plastic Molds ... Interchangeable Punches and Dies ... Production Parts  
Sheet Metal Dies ... Jigs and Fixtures ... Cold Forged Parts

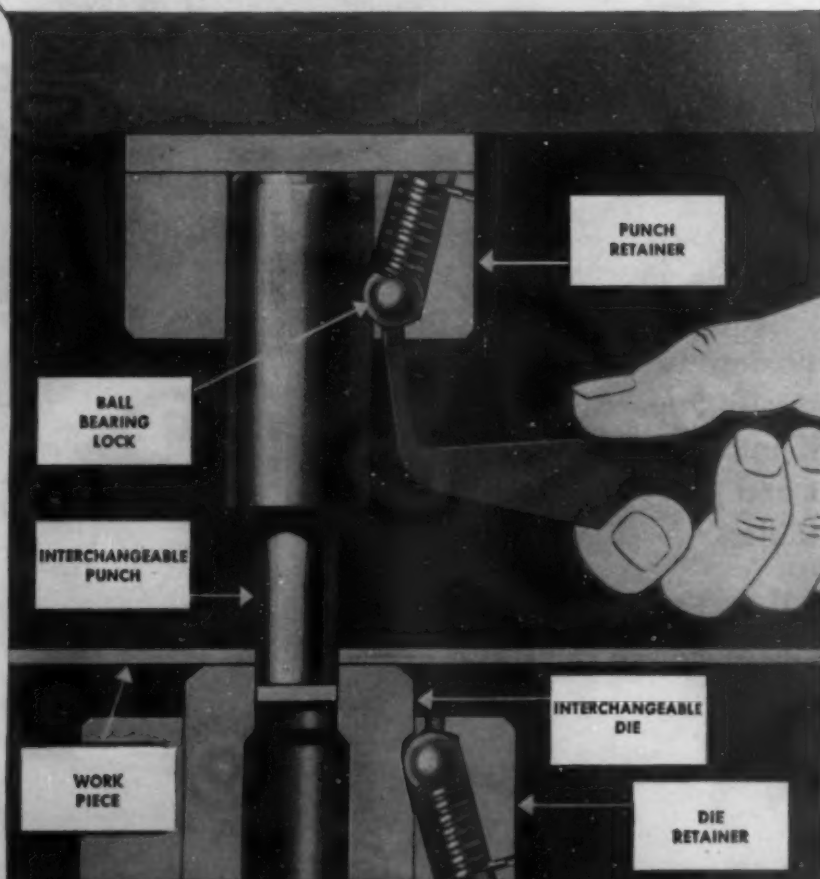
BUY MORE WAR BONDS



## The Original Interchangeable Punch and Die

Perfected by Richard Brothers Division of Allied Products Corporation, this unit is now widely used in all metal working fields. Standard size square, round or end retainers are of case-hardened steel. The retainer is fitted with a patented ball bearing and spring lock which holds the punch or die securely but permits easy changing without removing the die from the press. Interchangeable punches are of water-hardened steel, rigidly tested and inspected. Carried in stock in a wide range of standard sizes. Special size retainer plates, punches and dies made to order. Write for the complete R-B catalog.

**"IT'S AN  
ALLIED PRODUCT"**



Illustrated above is a complete Richard Brothers Interchangeable Punch and Die assembly showing the method of releasing either the punch or die simply by depressing the ball bearing with the special hand tool provided.

**"SERVICE WITH A PUNCH"**

ANOTHER STEP TO AID IN

*“Serving Industry...  
Which Serves Mankind”*

MONSANTO CHEMICAL COMPANY, producer of more than 300 basic chemical and plastics products, announces acquisition of I. F. Laucks, Inc., world's largest manufacturer of industrial glues.

Through this step, Monsanto rounds out a complete service to another of America's basic industries . . . the forest-products field. These combined facilities include:

*I. F. Laucks, Inc., experience of more than two decades; PLUS the Laucks personnel, maintained intact to provide the individualized and specialized service for which Laucks is famous; PLUS the I. F. Laucks, Inc., plants in Seattle, Vancouver, B. C., and Los Angeles and other Laucks, Inc., interests elsewhere in the United States, Canada and overseas*

*...PLUS the six Monsanto research laboratories, including a central research laboratory—one of the largest in this country devoted exclusively to advance industrial research*

*...PLUS nineteen Monsanto manufacturing plants in the United States and additional plants in England, Wales, Canada, Australia and Brazil—producing a range of commodities extending from heavy chemicals through fine pharmaceuticals and food chemicals to one of the widest ranges of plastics in existence*

*...PLUS facilities to supply raw materials for existing and potential forest-product applications that are possible only in an integrated operation such as that now afforded by the union of Laucks and Monsanto.*  
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**6 MILLION PERFECT PARTS  
PRODUCED BY DIES MADE  
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During the past five years, one set of progressive operation dies made of Graph-Mo Steel produced 6,000,000 clutch housings for automobile window regulators.

Even with this impressive record, these dies are continuing to provide trouble-free performance and to produce perfect, scratch-free parts that are accurate to .002".

This kind of proven performance is responsible for the steadily increasing popularity of Graph-Mo and the other Graphitic Steels, Graph-Tung, Graph-Sil, Graph-Al and Graph-M.N.S.

Include these five steels in your Post War plans. They will increase production and cut costs because they wear longer, they machine at least 25% faster than competing steels and they have less tendency to score work.

One of our metallurgical engineers will be glad to recommend the proper Graphitic Steel for any specific application you have in mind. Steel and Tube Division, The Timken Roller Bearing Company, Canton 6, Ohio.

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**GRAPHITIC STEELS**



*Plastic Parts of Every Description*

**ST. LOUIS PLASTIC**  
MOULDING COMPANY  
SAINT LOUIS  
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PIPE **SARAN** TUBING  
MOULDED PARTS

# HE MOUNTED HIS HORSE AND RODE OFF IN ALL DIRECTIONS



HE famed copybook error has nothing on the plastics industry.

Plastics are really moving. And they are moving in all directions at once—something like an exploding charge of TNT.

The dynamics are not something we claim to comprehend. We're only molders, not economists or statisticians.

We've watched the number of raw materials grow—seen the perfection of each—watched the new applications pour forth. In fact, we've contributed a few applications ourselves, and even designed some equipment to help keep the party lively.

All in all, plastics are fascinating materials and if you haven't found out about them yet, you should.

Perhaps we may be able to help you. We mold all of the moldable ones and have been for some time.



"A Ready Reference for Plastics" written for the layman, is now in its seventh edition. If you are a user or a potential

user of molded plastics, write us on your letterhead for a copy of this plain non-technical explanation of their uses and characteristics. Free to business firms and government services.



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MOLDERS OF PLASTICS • PHENOLICS • UREAS • THERMOPLASTICS

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NEW YORK OFFICE

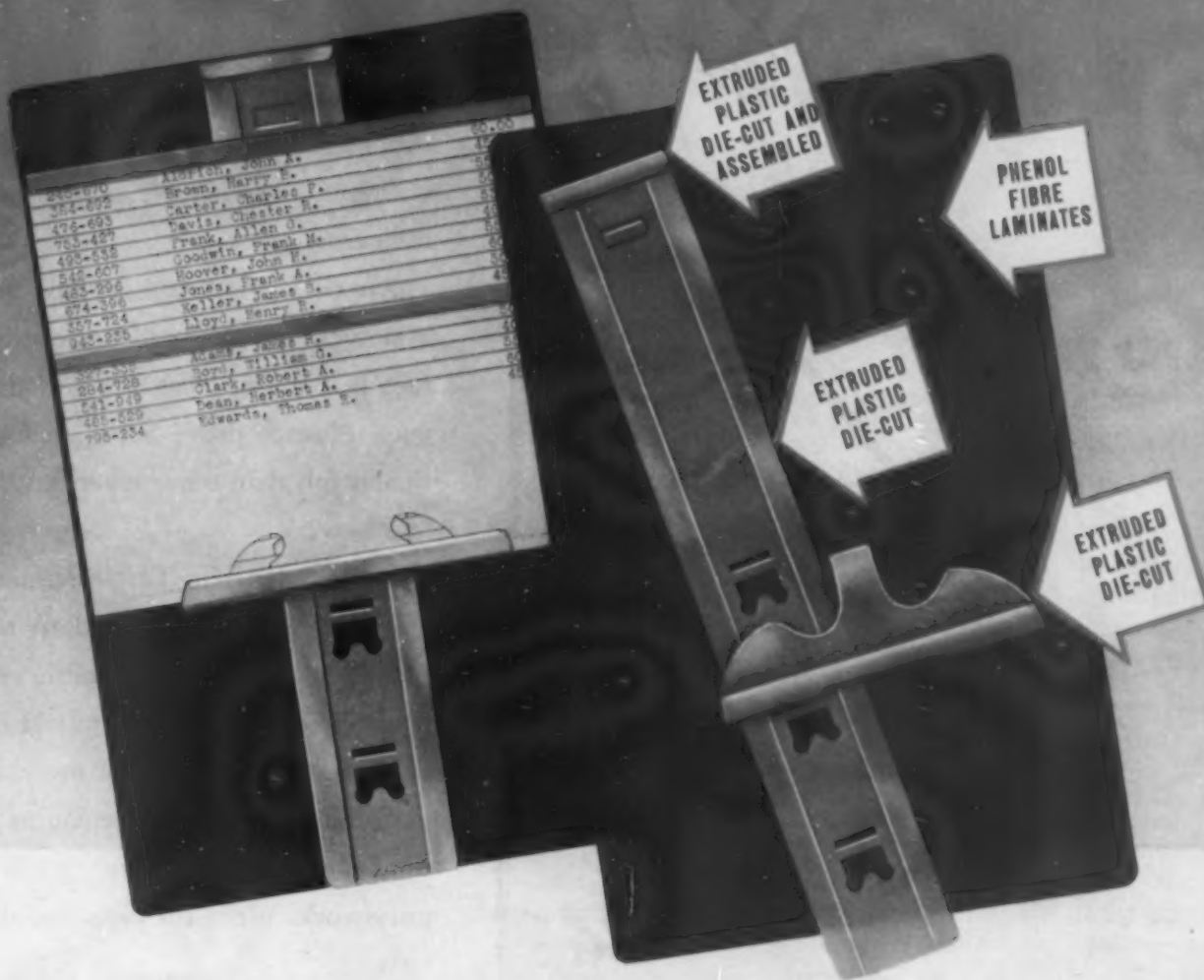
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and  
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**BY**

# PLASTEX



## EXAMPLES OF PLASTEX EXTRUSIONS



**PROTECTIVE  
GLASS  
EDGINGS**



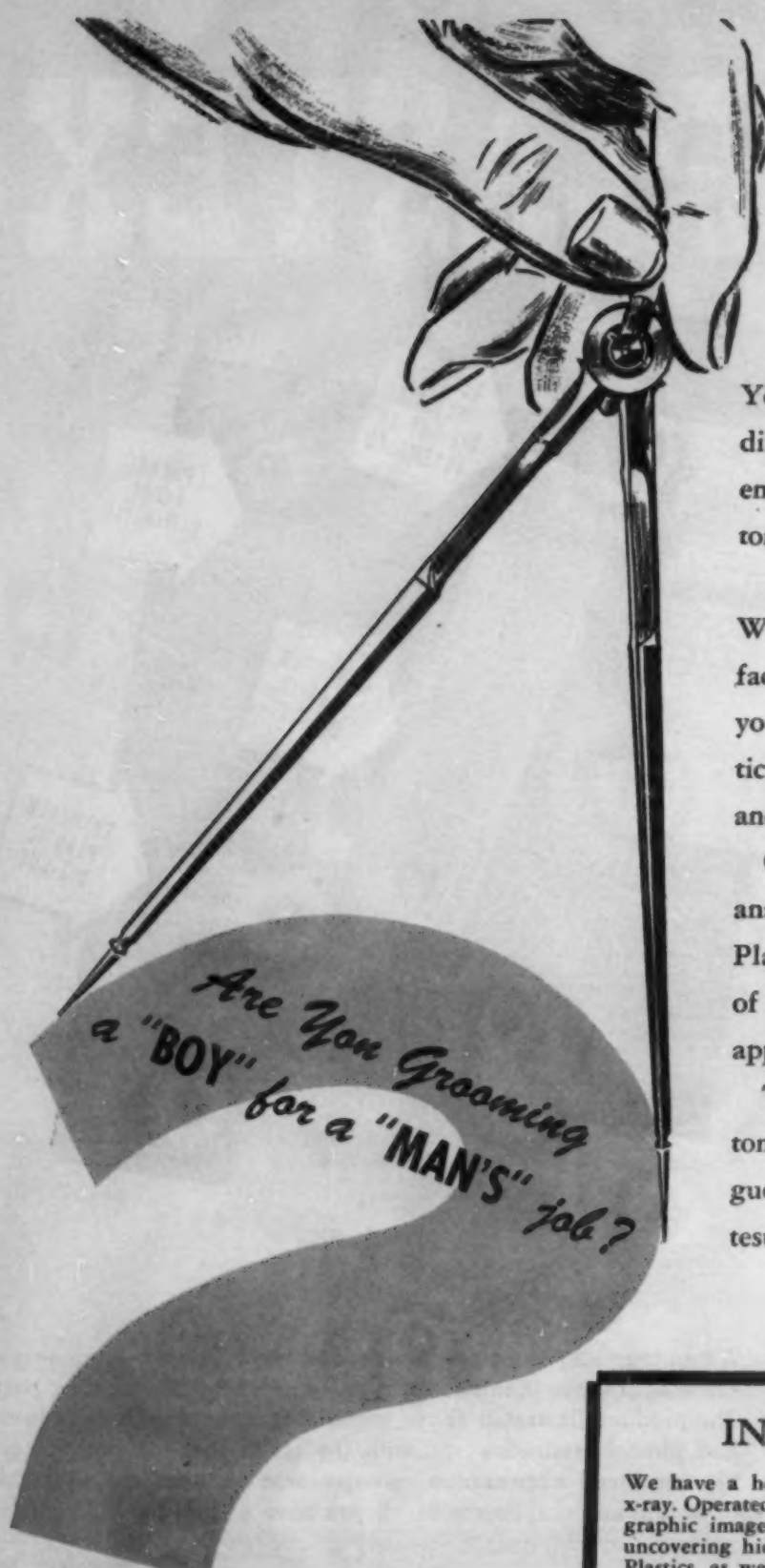
**PROTECTIVE  
LINOLEUM  
EDGINGS**



An outstanding example of the ability of Plastex engineers to assist aggressive manufacturers in redesigning products or parts. The product illustrated above is made entirely of extruded plastics and phenol laminates . . . with the result that the product now has improved appearance, greater ease in handling, is lighter in weight and non-corrosive. If you have a problem of production for war or of planning for peace . . . contact us today.

# • PLASTEX •

THE PLASTEX CORP. • COLUMBUS, OHIO



Your Plastics will have to meet new conditions . . . fit new requirements . . . do an entirely different job in the world of tomorrow.

Are they equal to these new demands? Will your Plastics sell as readily in the face of competition as they do today? Will your Plastics prove superior for a particular job than other materials, both old and new?

Only Scientific Testing has all the answers. We are prepared to test your Plastics from every conceivable viewpoint of serviceability . . . and to test them for application to any type of use.

These facts will enable you to plan for tomorrow with certainty . . . instead of guesswork. Write for price list of routine tests.

### INDUSTRIAL X-RAY

We have a heavy-duty, Westinghouse 220 kv industrial x-ray. Operated by skilled technicians, trained to read radiographic images properly, this x-ray is now available for uncovering hidden structural defects in products made of Plastics, as well as other materials. Write or phone for a personal meeting with our x-ray engineers . . . either here or at your plant.



• Member of A.C.C.L.

\* American Council of Commercial Laboratories

**UNITED STATES TESTING COMPANY, INC.**

ESTABLISHED 1880

**HOBOKEN, NEW JERSEY**

PHILADELPHIA, PA.

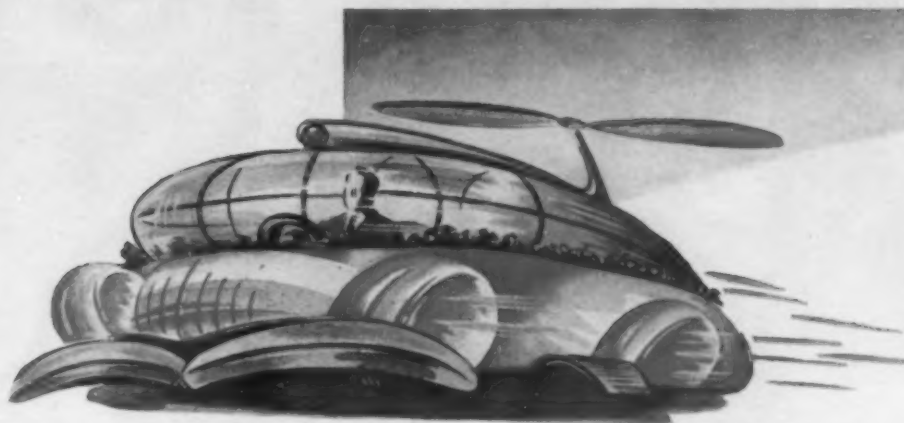
GREENSBORO, N. C.

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CHICAGO, ILL.

NEW YORK, N. Y.

# That Postwar Car



We Don't Know What It Will Look Like, But We Do Know...

It hasn't been the custom of this company to indulge in whimsies or dreams. We deal in plastics—extruded plastics. True, many applications that were considered almost fantastic a few years ago have become realities through **MACOID** developments. Our interest lies in the realistic approach to definite industrial problems.

On the post-war car, we offer no flights of fancy. We offer extruded plastics, both rigid and flexible. We intend to make them in the profiles that designers will need. Developments are still in the making. We are working now with "feet-on-the-ground" designers and engineers who are working to build—not dream—post-war vehicles.

We also do injection molding.



ORIGINATORS OF DRY PROCESS PLASTIC EXTRUSION



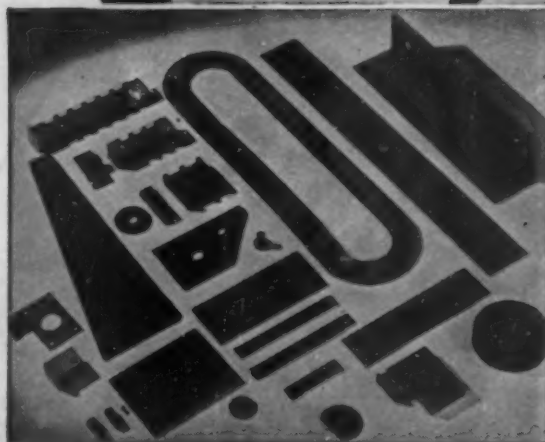
**L**IGHTER weight, greater speed, higher safety standards, longer life, lower travel and transportation costs . . . have been the lengthening shadows which have forecast our modern methods of overland transportation.

One C-D product, **DIAMOND** Vulcanized **FIBRE**, early presaged revolutionary design changes. **DVF** is a tough, strong **NON-metallic**, with an extremely favorable, strength-weight factor when compared to metals. It has a natural resilience and great ability to absorb shocks and vibration. It is a good electrical insulator. It is readily punched, machined or formed.

In 1911 C-D introduced **DILECTO**, a laminated plastic, first called "waterproof fibre." **DILECTO** has played an equally important part in helping advance transportation methods. Wherever electricity must be controlled C-D **DILECTO** provides insulation that stands up under extreme conditions of temperature and moisture.

In adapting these and the other C-D **NON-metallics** to the "What Material?" problems of peace and war, the C-D laboratory has acquired a wealth of "know how" which is at your disposal to help you solve your "What Material?" problem.

DISTRICT OFFICES: New York - Cleveland - Chicago - Spartanburg, S. C. West Coast Rep., Marwood, Ltd., San Francisco - Sales Offices in principal cities



C-D products include **THE PLASTICS** . . . **DILECTO**—a laminated phenolic; **CELORON**—a molded phenolic; **DILECTENE**—a pure resin plastic especially suited to U.H.F. insulation . . . **THE NON-METALLICS**, **DIAMOND** Vulcanized Fibre; **VULCOID**—resin impregnated vulcanized fibre; and **MICABOND**—built-up mica insulation. Folder **G7** describes all these products and gives standard sizes and specifications.

CJ-48

**Continental - Diamond** FIBRE COMPANY

Established 1895. Manufacturers of Laminated Plastics since 1911—NEWARK 28 • DELAWARE

THE FIRST INDUSTRIAL HIGH FREQUENCY DIELECTRIC HEATING EQUIPMENT

# Designed for *Plastics*



THE NEW  
No. 2P  
THERMEX

**FULLY AUTOMATIC AND 100% PORTABLE**

The new No. 2P Thermex gives you every reason for using high frequency preheating *now*. It is simplicity to the nth degree — convenient, practical, flexible. Just roll it to the work, plug it in and start operating. Heat preforms one at a time or a tray-full . . . *perfectly . . . fast and thoroughly . . .* at the rate of up to *a pound a minute*. Years of high frequency development and work with the plastics industry preceded the design of the Thermex 2P unit. This knowledge of plastics requirements produced features such as the enclosed preheater cabinet, removable drawer-electrode, single timer adjustment and many other engineering "firsts." The Girdler Corporation, Thermex Division, Louisville 1, Ky.

**Thermex**  
A GIRDLER PRODUCT



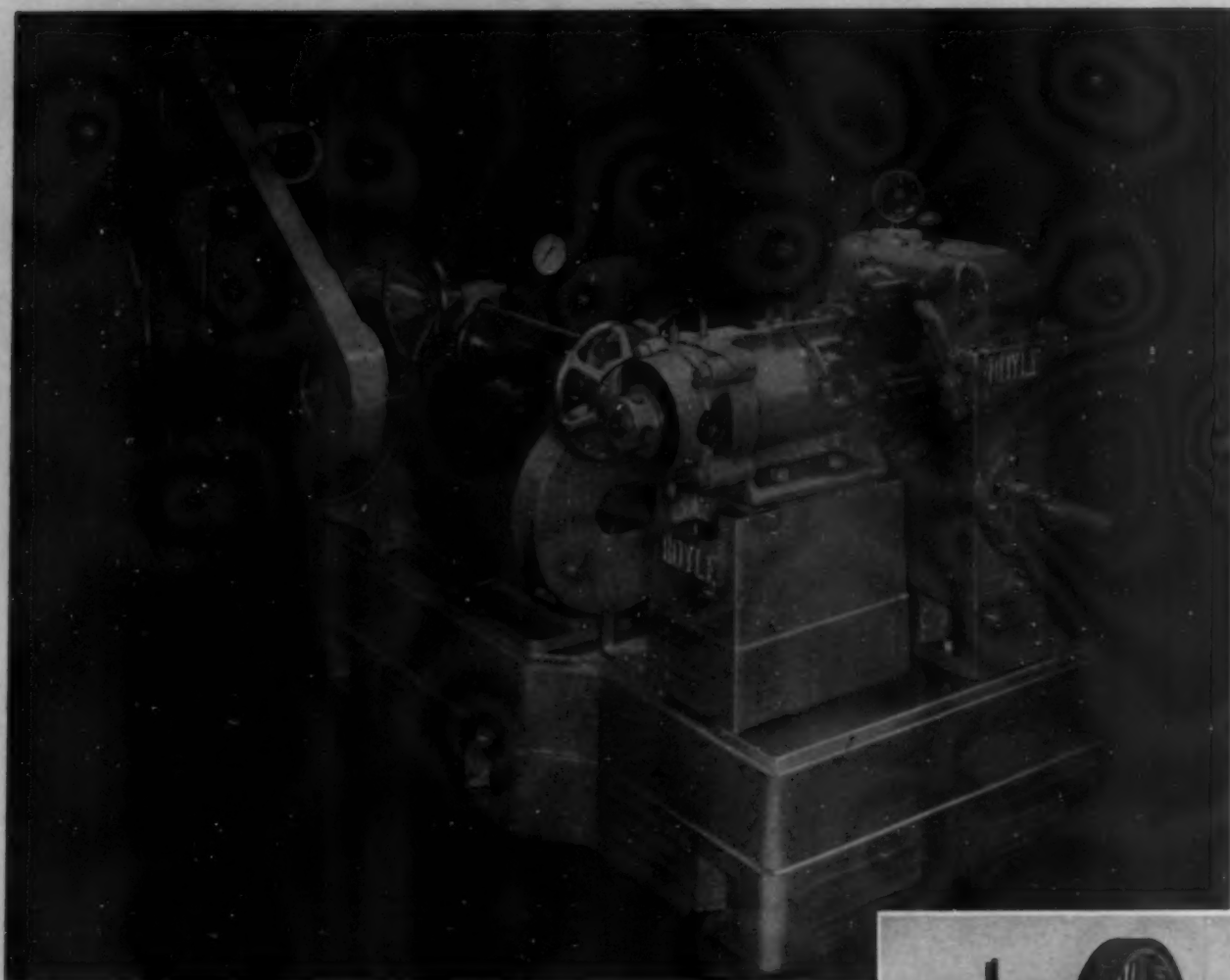
FILLING THE DRAWER



CLOSING DRAWER TURNS ON HF POWER



REMOVING FULLY HEATED PREFORMS



No. 2 Royle Continuous Vulcanizing Machine equipped with Stock Screw Speed Tachometer and Sperry Exactor Control.

## Extruding in 1944 with a 1905 Royle Tubing Machine

Yes, it is being done. Not in one isolated plant but in many where ingenuity has been substituted for modern machines. These processors have done a grand job in literally interpreting "make it do."

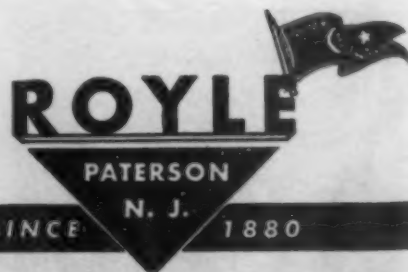
Essentially the continuous extrusion process hasn't changed a great deal since John Royle & Sons first introduced it sixty-four years ago. There have been refinements—the most apparent being in the field of temperature control and in the development of accessory equipment.

When the war has been won these "turn of the century" tubers will be retired for modern machines. The post-war Royle Extruder probably won't be a startling revelation. Into it will go all of the "know how" gained from pioneering in the continuous extrusion machinery field since 1880.



No. 2 Royle Tubing Machine of 1905

# JOHN ROYLE & SONS



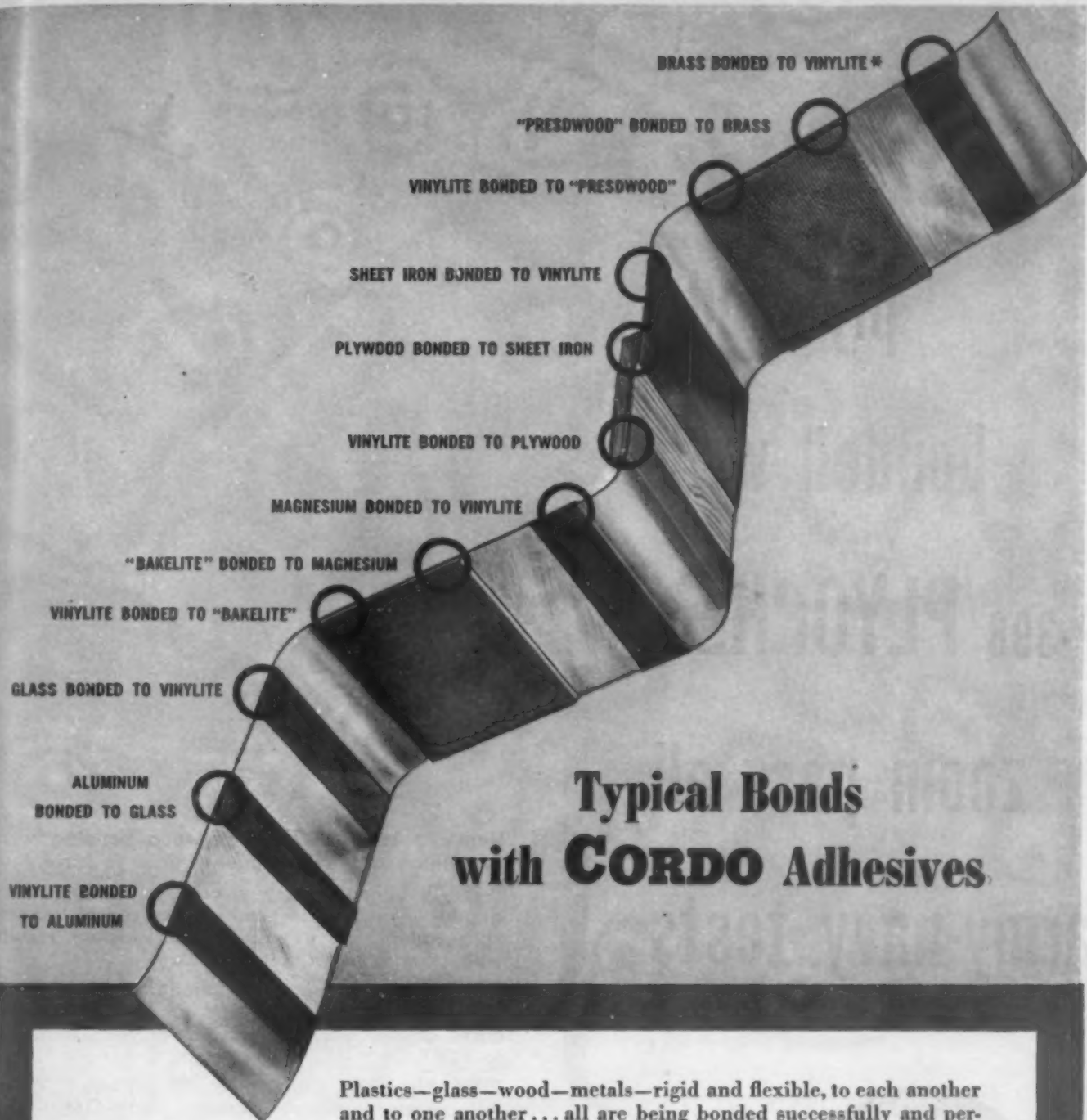
PIONEER BUILDERS OF EXTRUSION MACHINES SINCE 1880

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James Day (Machinery) Ltd.  
London, England

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B. H. Davis J. W. VanRiper  
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## Typical Bonds with **CORDO** Adhesives

*Actual Photograph*

Plastics—glass—wood—metals—rigid and flexible, to each another and to one another... all are being bonded successfully and permanently with CORDO Adhesives.

A constantly increasing range of adhesive types is being developed for specific bonding problems, strengths, applications. Within this range or in the laboratory stage may be the solutions to some of your present or post-war bonding problems.

Please write, giving all essential data: bond strengths necessary, service requirements, materials to be used, pressure and baking methods available.

\*VINYLITE IS THE REGISTERED TRADE MARK OF CARBIDE AND CARBON CHEMICALS CORPORATION

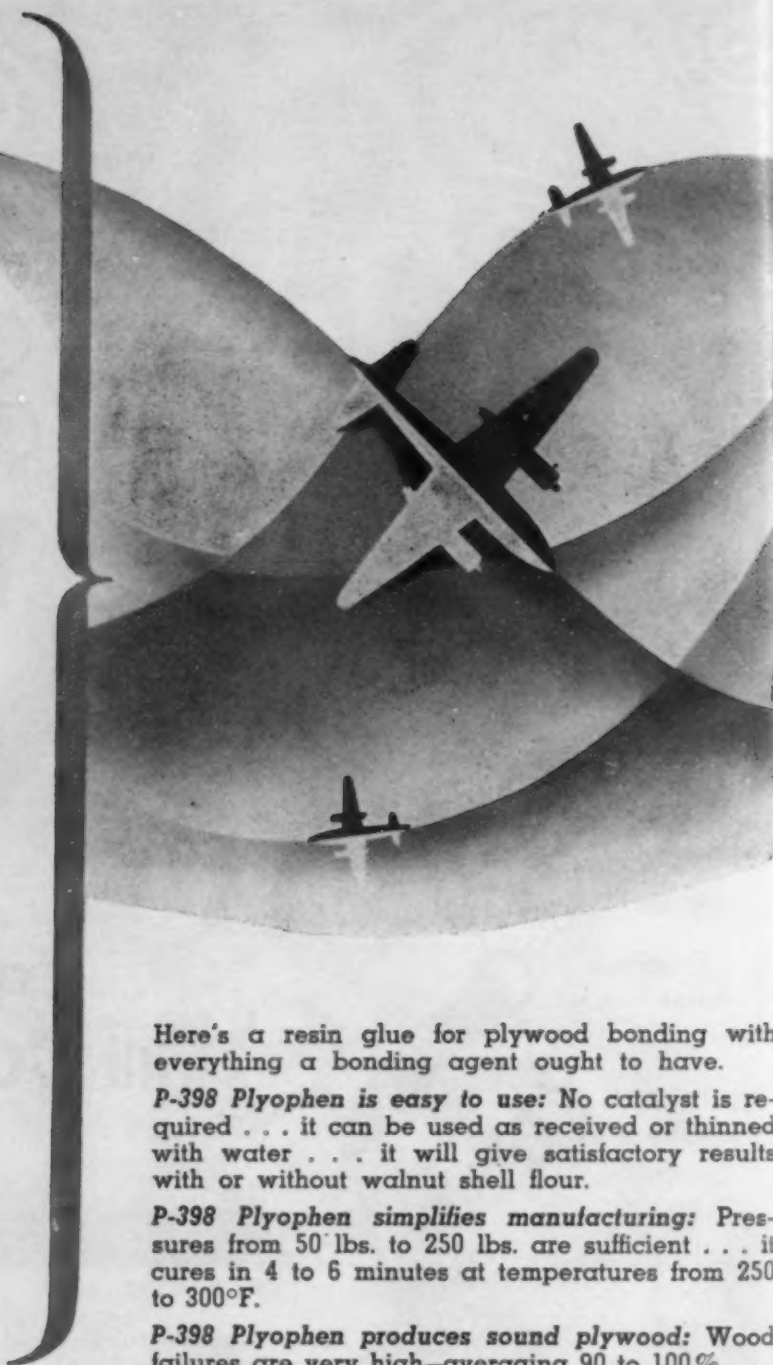
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34 Smith Street, Norwalk, Connecticut

INDUSTRIAL COATINGS • FINISHES • INDUSTRIAL ADHESIVES

# CORDO

plywoods  
bonded with  
**P-398 PLYOPHEN**  
zoom past all  
army-navy tests



**REICHHOLD CHEMICALS, INC.**

General Offices and Main Plant, Detroit 20, Michigan

Other plants: Brooklyn, New York • Elisabeth, New Jersey • South San Francisco, California • Tuscaloosa, Alabama • Liverpool, England • Sydney, Australia  
**SYNTHETIC RESINS • CHEMICAL COLORS • INDUSTRIAL PLASTICS • INDUSTRIAL CHEMICALS**

Here's a resin glue for plywood bonding with everything a bonding agent ought to have.

*P-398 Plyophen is easy to use:* No catalyst is required . . . it can be used as received or thinned with water . . . it will give satisfactory results with or without walnut shell flour.

*P-398 Plyophen simplifies manufacturing:* Pressures from 50 lbs. to 250 lbs. are sufficient . . . it cures in 4 to 6 minutes at temperatures from 250 to 300°F.

*P-398 Plyophen produces sound plywood:* Wood failures are very high—averaging 90 to 100% . . . break tests, wet and dry, are well over Army-Navy Aeronautical Specifications AN-NN-P-511b—as well as Commercial Standards CS45-42 for exterior types of Douglas Fir plywood.

Just as important—*P-398 Plyophen is available in volume*—as are all the RCI phenolic bonding and impregnating resins in the extensive Plyophen line.

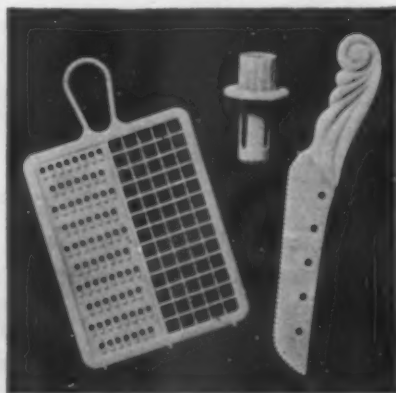
Write for exact details of numerous tests and recommended application methods direct to the Sales Department in Detroit.



# Did 'ja Ever See A Post-War Rabbit!



No prompting from the audience, please! Our prestidigitator is well aware that this war won't change the physical characteristics of Peter Bunny. Post-War or Pre-War . . . both are conceived in the same mold . . . made of identical materials.



Plastics are light in weight, easy to handle, add color and cheer to humdrum kitchen tasks. The Juice Extractor, Fruit Knife and Grater shown here, are definitely not Post-War Rabbits. They'll be molded of plastics, come peace-time!

We notice with considerable apprehension, the application of plastics as substitute materials (due to shortages, priorities, etc . . .) to a multitude of products. Products that "belong" in other materials. When conditions return to normal, these products (same as Peter Bunny) will be created from the original mold . . . made of the identical materials used in Pre-War days. That's why we call them Post-War Rabbits.

PRECISION engineers are versatile. We have had experience in introducing many entirely dissimilar industries and items to plastics. In every case the application was right . . . not a Post War Rabbit in the lot! Feel free to use our experience when considering plans for your future business. We are eager to create new and better products of plastics . . . properly!

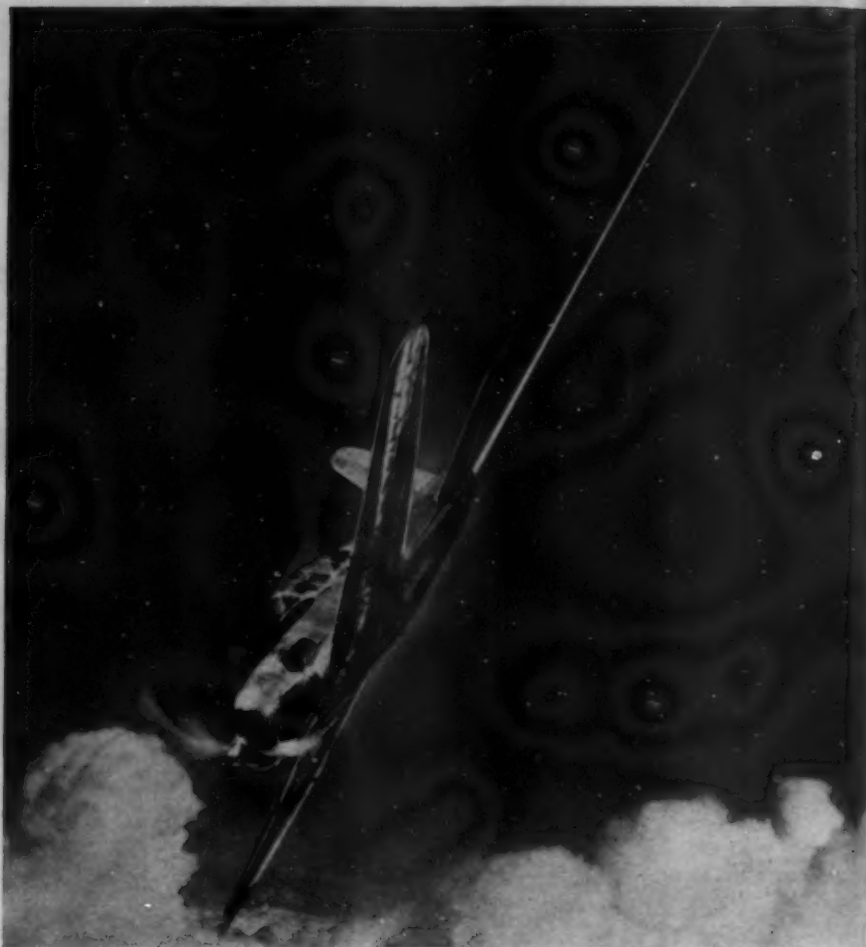


## PRECISION PLASTICS COMPANY

1724 W. INDIANA AVE., PHILADELPHIA 32, PA.

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VULTUR AIRCRAFT, INC.

# SKILL



**T**HE superior skill of American pilots is winning air battles on every fighting front. In the same sense, it's the superior skill and the long experience of Sinko Plastic Engineers which are responsible for the extraordinary success of so many intricate Sinko Injection Moldings.

Sinko has been making better tools and dies for 25 years . . . and better injection moldings ever since thermoplastics were introduced. Small wonder we've developed superior methods and

techniques, an unsurpassed knowledge of simple and intricate steel reinforced injection molding. Many peacetime products we've made have helped to capture coveted markets. For your own best interests, discuss your post-war plans and products with a Sinko engineer, NOW!



**SINKO TOOL & MANUFACTURING COMPANY, 351 NO. CRAWFORD AVENUE, CHICAGO, ILLINOIS**

REPRESENTATIVES: L. D. MOORE, 4030 CHOUTEAU AVE., ST. LOUIS, MO. • POTTER & DUGAN, INC., 29 WILKESON ST., BUFFALO, N. Y. • ARCH MASON, 259 CENTRAL AVE., ROCHESTER, N. Y. • H. O. ANDERSON, 202 HERALD BLDG., SYRACUSE, N. Y. • PAUL SEILER, 7779 CORTLAND AVE., DETROIT, MICH. • QUEISSER BROS., 108 EAST NINTH ST., INDIANAPOLIS, IND.





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# Thermosetting War Compounds

have that extra something for trouble-production. We offer the following outstanding Phenolic thermosetting resins in their particular fields:

## GENERAL PURPOSE

lot #1163—Available for CFG contracts. Unsurpassed in molding and quality.

lot #1962—Special General purpose. Supreme for the past 7 years for satisfactory mold shrinkage. NEVER CRACKS AROUND INSERTS.

## IMPACT

**alot #93C—For CFI-10 work. Approaches CFI-20 in strength, yet has flowing and molding qualities equal to many wood-filled compounds.**

**Lot #95—Equivalent in impact strength to CFI-20 requirements.**

alot #1905—Recommended for M52 Fuze molding.  
High degree of flexibility to withstand expansion and  
contraction strain of inserts.

lot #1804—Improved Impact—preforms and molds  
the general purpose, but has an impact strength 25%  
to 30% higher.

## ELECTRICAL

**Kalot #1040**—The best molding Low Loss compound yet developed for MFE work.

**Calot #277-D—Combines both heat and electrical quali-**

## HEAT RESISTING

**Patent #7580—Meets Underwriters Laboratory specifications for Heater plugs.**

**Alot #75-D—Highest heat resistant material. Superior holding qualities, no sticking.**

## CONSERVE PHENOLICS!! SPECIFY:

# MAKALOT K.E.M.



This ATTRACTIVE CAFETERIA TRAY, molded from K.E.M.—15% Phenol, is being used to serve Food to the ARMED FORCES, DEFENSE PLANTS and HOSPITALS. Molded under the same general conditions as Phenolics, vast savings in both Phenol and Formaldehyde are effected. K.E.M. is a semi-critical compound, requiring only minimum amounts of Formaldehyde. The Phenol used varies from Zero to 15%. Everything from the long narrow Bomb Boosters to small bottle closures have been molded of K.E.M. by Compression and Jet Process.

**AND NOW!!**—We have developed K.E.M. RESINS for laminating and impregnating of wood, paper, textiles, etc. Available in solid form, alcoholic solutions or in water miscible form. Write us for full details.

## SPOT NEWS!

Have you tried MAKALOT'S ADHESIVE #301? This new idea in thermoplastic adhesives is the answer where a really effective seal against water and alcohol are required.

**ADHESIVE #301** can be used for either air or heat drying conditions. Application is by brush, dip or spray methods.

## A TRULY EFFICIENT ADHESIVE

**M**  
Central States R

## "KEEP 'EM MOLDING"

# Makalot

CORPORATION

210 WASHINGTON ST. BOSTON 6, MASS.

**262 WASHINGTON ST., BOSTON 9, MASS.**  
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**Pacific Coast Representative:**  
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## The Independent Producer of Superior Plastics

## THEY'LL HANDLE MOST OF YOUR PLASTIC FILING JOBS



**CURVES**—holes—corners—straight edges and surfaces—square and “V” notches. . . Hard—soft—laminated—shreddy materials. . . Roughing—reaming—smoothing—fitting. In these are found practically all of the conditions or factors involved in filing plastic products. The file cross-sections indicated above, in varying cuts, will ordinarily meet all or any combinations of them.

The most commonly required standard file sizes are 6”, 8” and 10”—with smaller-size special files (usually in Swiss Pattern) often needed on small, intricate instrument parts; and larger sizes on big units such as aircraft wing and fuselage forming dies.

**BUT**—files for plastics should, as a rule, have these important individual features:

- (1) Comparatively wide gullets to minimize clogging—especially when used on shreddy materials.
- (2) High, thin-topped teeth for fast cutting and to maintain serviceable cutting edges for a long time under the abrasive action of most types of plastics.

### NAME THE JOB AND WE'LL NAME THE FILE

The best assurance of getting *The right file for the job* is to specify Nicholson or Black Diamond Files marked or recommended “For Plastics.” Nicholson has made a careful study of files for the plastics industry. Our engineers will help you in solving any special filing problem. Contact us direct or through your mill-supply house.

**FREE BOOK, “FILE PHILOSOPHY,”** on kinds, use and care of files—48 illustrated pages of interest to production and purchasing heads, foremen, mold and die makers.

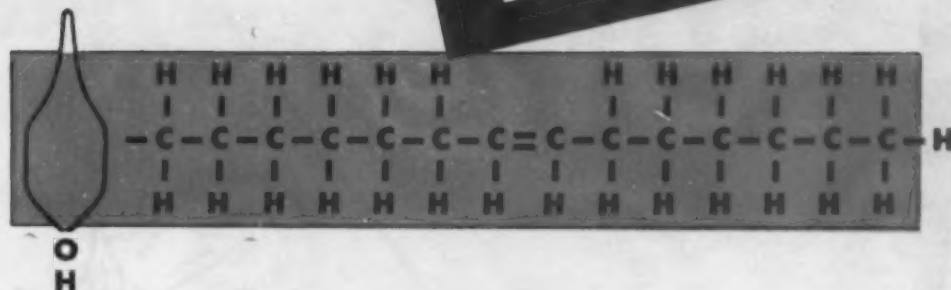
**NICHOLSON FILE COMPANY • 44 ACORN STREET, PROVIDENCE 1, R. I., U. S. A.**  
(Also Canadian Plant, Port Hope, Ont.)

**NICHOLSON FILES**  
FOR EVERY PURPOSE

**NICHOLSON**  
**U.S.A.**  
MADE IN U.S.A.

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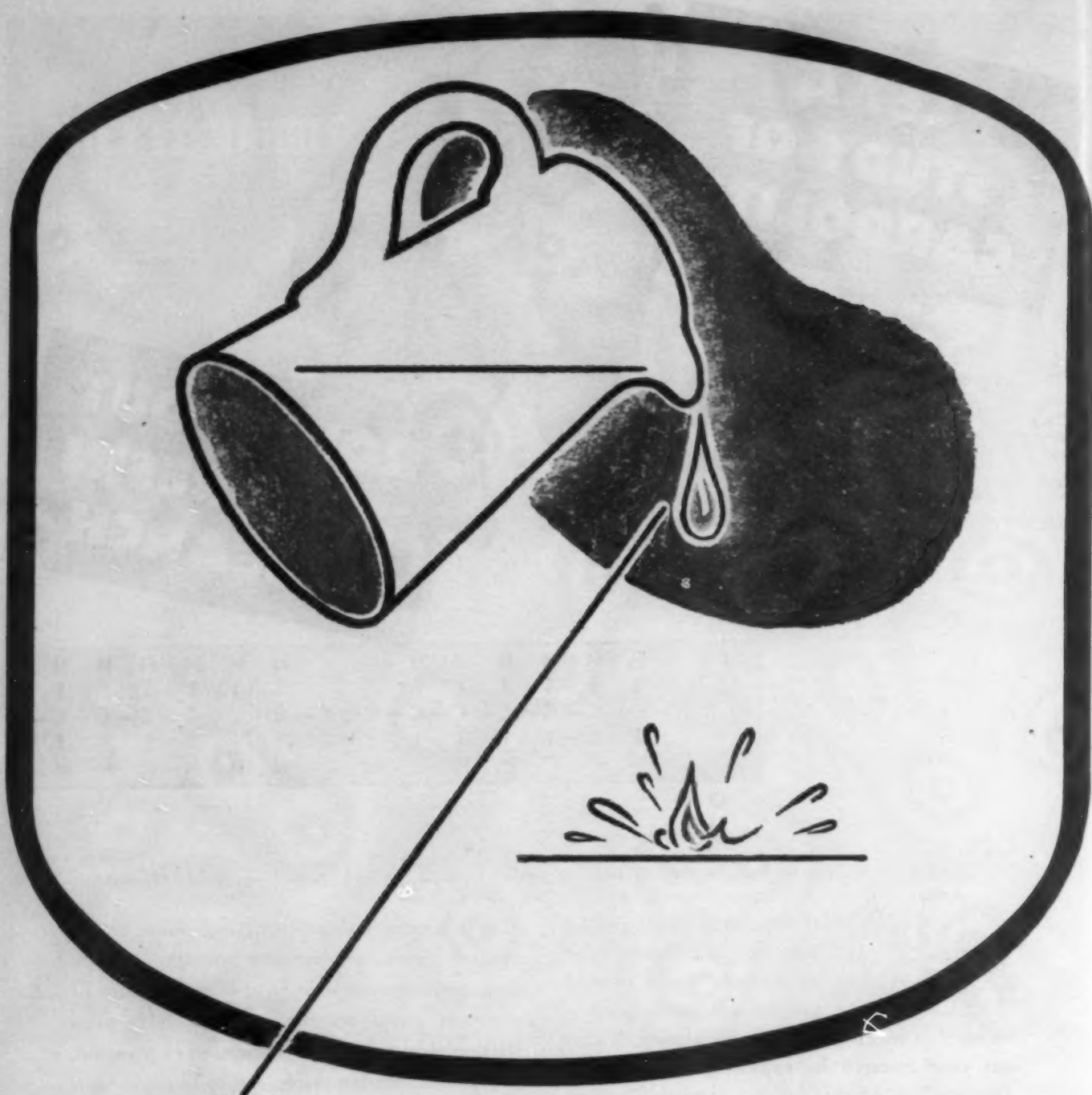
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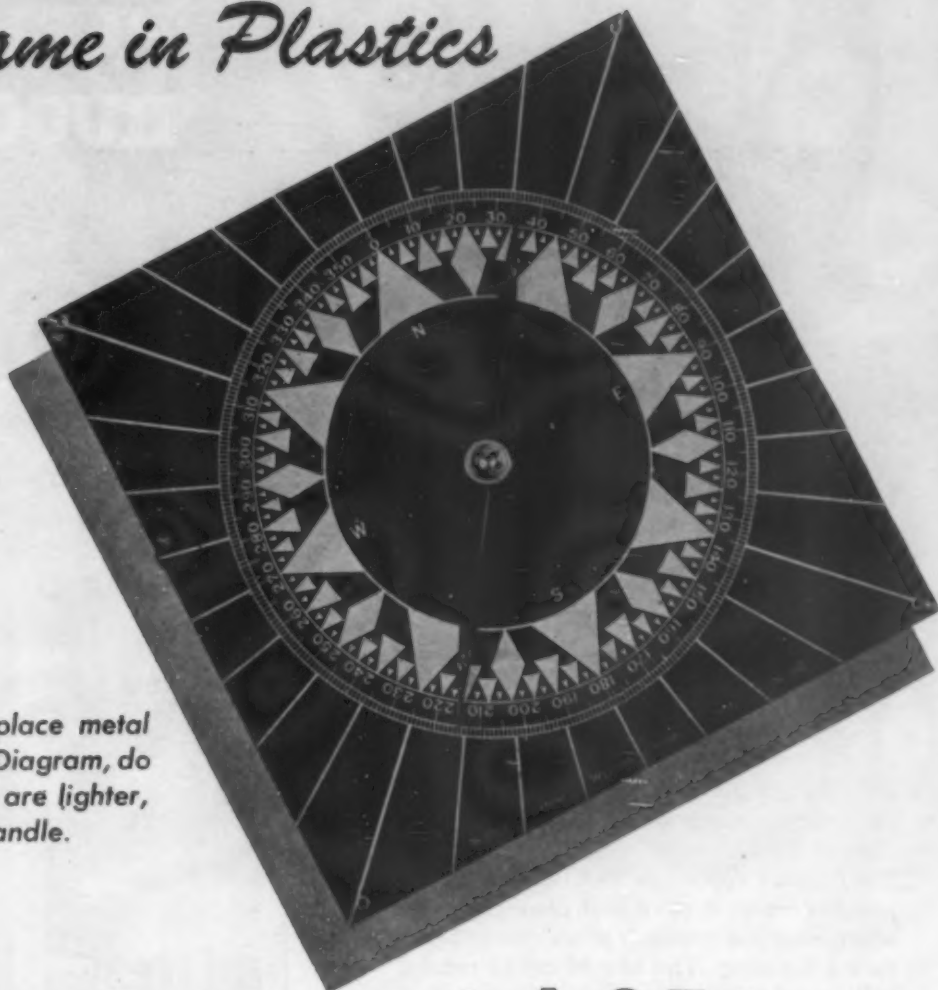
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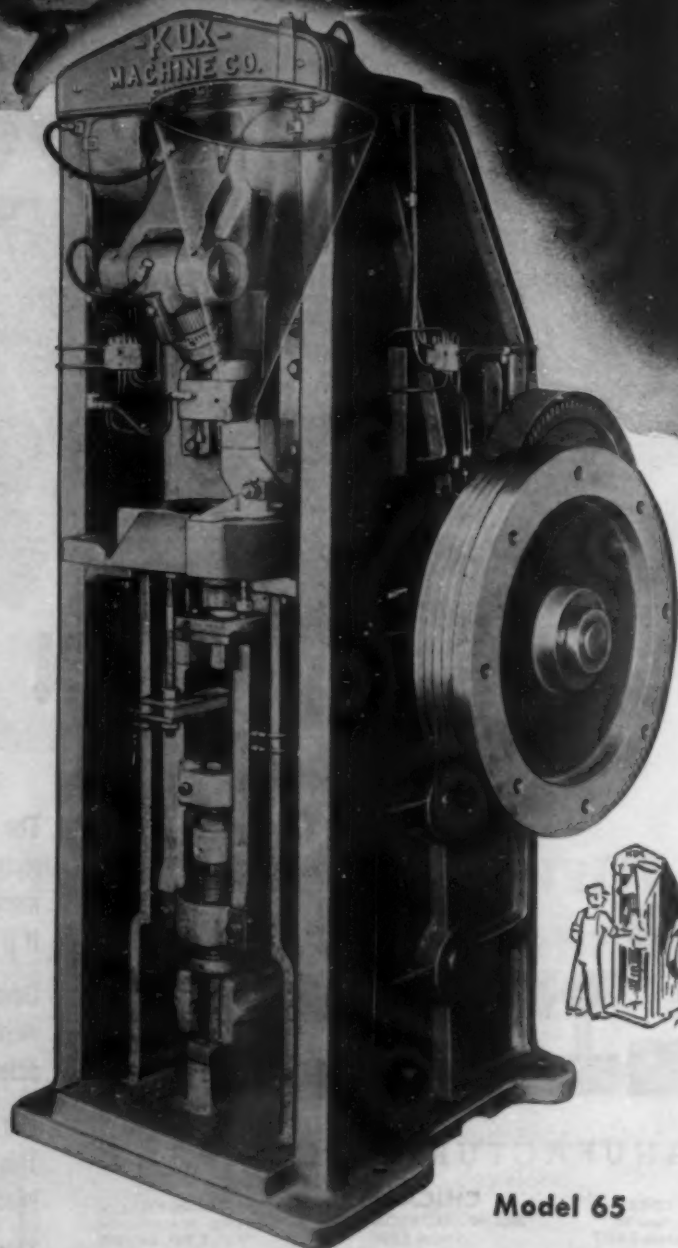
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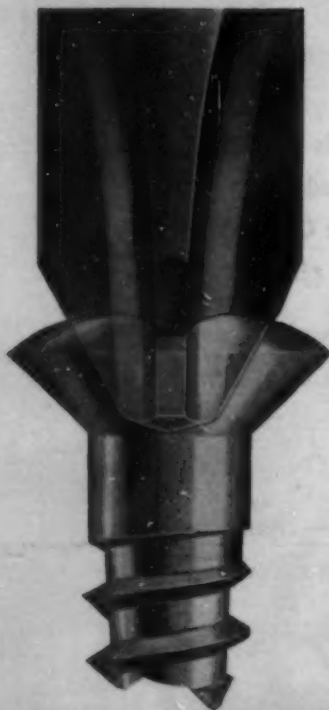
THE TAPERED RECESS HOLDS DRIVER FROM SLIPPING



**NOTE CLEAN APPEARANCE OF PHILLIPS SCREW**  
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**NOTE MARRED SLOT OF ORDINARY SCREW**  
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# MODERN PLASTICS

MAY 1944

VOLUME 21

NUMBER 9

## The ups and downs of color

"WHEN I get out of this war," growled one gloomy G. I. Joe, yanking viciously at his drab neckwear, "I'm going to buy the damndest gaudiest necktie I can find."

This active distaste for khaki and olive drab is the normal reaction of the service man to the sights, surroundings and habiliments of war. Although the American soldier is the best outfitted and the most comfortable fighting man in the world, the comparison is distinctly relative. The thought that he is better equipped for battle than, say, the Chinese soldier, brings him scant solace when he contrasts his somber surroundings with the remembered warmth, color and cheerfulness of home.

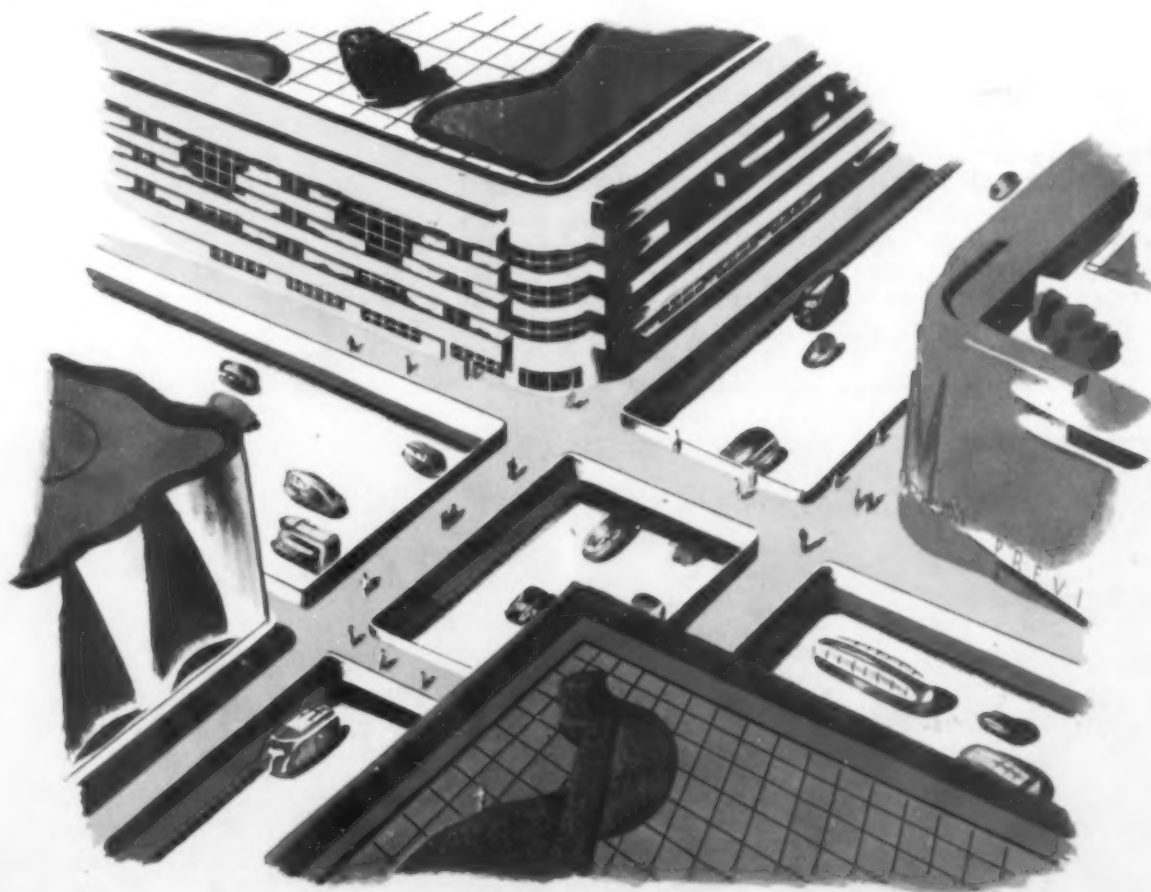
Already the prognosticators are writing columns of speculation on the presumed temper of the soldier returned from the wars. He will be, variously, an enthusiastic

internationalist and a determined isolationist; a distinct cosmopolitan, his outlook broadened by sojourn in other lands, and a confirmed provincial, devoted to the home town and the *status quo ante*; a sentimentalist who wants to find things as he left them, and a progressive chap who hopes that there have been improvements. On one point, however, all self-appointed spokesmen for the homing warrior seem to agree: he will want to see lots of bright, cheerful color.

The tendency of color incidence to drop in time of war has been statistically attested to by those who note and chart such phenomena. Obvious reasons for its disappearance are the unavailability of dyestuffs and the machinery used in their manufacture, the manpower shortage and the cost factor. Another, more intangible cause of the

1—The city of the future will be colorful as well as architecturally functional. A street intersection designed by Norman Bel Geddes for the General Motors Futurama at the New York World's Fair suggests a variety of plastic applications

PHOTO, COURTESY NORMAN BEL GEDDES & CO. COLOR RENDERING BY NOAH BEE, MODERN PLASTICS ART STAFF



change is psychological: anxiety and grief are reflected in an avoidance of the gay and garish in apparel and surroundings. And finally, materials, like men, have put aside their civilian dress, donned uniforms and overalls and gone to war.

### Plastics in battle dress

Because inherent color is one of their distinguishing characteristics, plastics, more than most materials, have been changed by the transition from peace to hostilities—so changed, indeed, that even their best friends don't know them. It is estimated that 700 molders and laminators and 2300 fabricators turned out in 1943 three times the volume they handled before the war, 85 percent of it going into war matériel and the remainder currently allocated to essential civilian and industrial requirements. Only the most discerning among their former users can look at today's ships, planes, tanks and guns and recognize, in their battle dress of black, gray, khaki and olive drab, the familiar plastics that in peacetime wore, like Joseph, coats of many colors.

The effect of these wartime duties on the color range of plastic materials has been to reduce it from the hundreds of available prewar shades to a bare handful consisting of, roughly, black, white, gray, dark blue, olive drab, khaki and clear transparent. For purposes of identification, a few bright colors persist in such items as knobs, handles, pointers, dials, tubing, insulation, lenses for light bulbs and the like.

In addition, there are several instances of functional color, such as the special red and green acetate used for goggles and windshield cover in blind-flying trainers; the red covers for light bulbs which prevent impairment of fliers' night vision; and the transparent blue window sheeting which helps shopkeepers in coastal areas to conform with dimout regulations. A few such mavericks as a bright red (to catch the eye) first aid kit, a pale green (to match the plane's interior) cabin ventilator, are the only other bright spots in the monotonous wartime scene.

The domestic front, unregulated by the G. I. color requirements, is slightly more cheering. A number of non-military plastic items have been classified as essential—though, to be sure, it has not been deemed essential that they be provided in their customary galaxy of tempting colors, and the civilian consumer has scratched along with

what he can get. One manufacturer of urea material (permitted for buttons, closures, containers and the like) reports a 44 percent drop in the number of colors used by his customers in 1942 and a further decrease of 7 percent the following year. By and large, for those who think of color as synonymous with plastics, statistics for the war years make depressing reading.

Perhaps the greatest change has been registered by the cast phenolics. These decorative materials have dropped from a prewar 100 percent color value to a point only slightly above the zero line. A few dials, knobs and pointers in identifying colors still remain, but because the white formulations have the greater strength, they have been selected for war applications.

Color in the phenolics (with the exception of utility browns and mottles) has gone from its customary 10 percent down to less than 1 percent, or practically out of the picture.

The thermoplastic color chart is correspondingly dreary. One manufacturer of methacrylate resins reports that only 12.1 percent of his output was in colors in 1942, and that in 1943 this small percentage dropped to 8.2. According to one materials man's figures, polystyrene which he supplied in the prewar period as 40 percent clear transparent, 25 percent standard colors and 35 percent special colors, he now sells exclusively in clear transparent and the ubiquitous olive drab.

The traditionally gay nitrate sheet, which one of its manufacturers listed as 80 percent colors before the war, now finds the bulk of its production in clear transparent; and the same company's acetate molding powder has gone from 70 percent colored to an uninteresting mixture of transparents and drabs.

The unnatural butterfly-to-cocoon trend of the cellulosic plastics is attested by the following 5-year chart:

	1939	1940	1941	1942	1943
	%	%	%	%	%
White and grays.....	1	2	2	1	0.5
Black .....	43	41	31	32	33.5
Colors .....	50	46	52	34	25
Transparent .....	6	11	15	33	41
	100	100	100	100	100

The materials manufacturer explains that the large percentage of blacks in 1939 is accounted for by increased

2—Plastics for the fighting man present a study in olive drab. Today, 85 percent of the industry's output goes into war matériel. 3—Scattered items like soap boxes, tooth brushes and mess trays serve to vary the G.I. color monotony

2

3



use of these materials for housings and interior parts of electrical equipment. The increase in transparents in 1940 marks the beginning of the defense program, and these percentages continue to go up as more transparents are manufactured for aircraft enclosures and gas mask lenses. Colored materials, which comprised 50 percent of this manufacturer's output in 1939, now constitute only 25 percent, and most of them fall in the G. I. range.

### Color isn't skin-deep

What the position of plastics will be after the war—the extent to which they will be used, the forms they will take—is as much a matter of conjecture as the end of the war itself, although the OWI has not, to date, cautioned us against speculating about it. Assuming that they will again be employed for the hundreds of applications in which they served successfully before Pearl Harbor, it is safe to predict that this prewar volume will be augmented by a certain number of their new wartime adaptations. In some fields, plastics used to replace scarce metals have proved in service to be superior to the original materials and will undoubtedly continue to be employed. From others, having done their wartime duty as substitutes, they will retire in favor of more suitable materials. Brand-new products engineered for plastics and redesigns of a certain number now unhappily housed in something else should provide a third outlet.

In the buyers' market that will succeed the return of full peacetime production, plastics will have to compete with metals, wood, glass, rubber and ceramics both in price and in quality of product. Of all the favorable attributes that will make them stout contenders—light weight, corrosion resistance, good electrical properties, dimensional stability, ease of forming—none will serve them better in a world weary of the dull and subdued than their unlimited color.

"Pure theories of color," as one writer slyly remarked, "are formulated by physicists, presumably for the purpose of annoying other physicists, since all theories manage to differ so widely." As such, they are not properly the concern of the layman who, nevertheless, without benefit of Ostwald or Munsell, knows what he likes. Without stopping to rationalize about it, he appreciates that he works better in a light, cheerful room, sleeps better in one whose furnishings are cool and restful, has more fun where the décor is bright and lively. Objects he sees about him ap-

pear large or small, heavy or light, hot or cold, stimulating or restful, pleasing or irritating, largely because of their color.

The kaleidoscopic colors by virtue of which plastics have the ability to determine man's many moods and to give charm and personality to a wide variety of products are no fragile esthetes. They have, on the contrary, a fine, sound, practical quality about them: they are firmly rooted in the material. Plastics' inherent colors won't wash off, wear off, chip, peel, crack, scratch or be affected by body acids. They are not applied as coatings in a finishing operation, but are molded into the products themselves and thus run straight through the plastic material. If the surface of a plastic piece is dulled by dust or handling, it can be restored to its original gloss and color value simply by wiping it briskly.

### Plastics in mufti

Emphasis on the color appeal of plastic materials is not a suggestion that their postwar applications will be purely decorative. Refurbishing the shabby scene will be one of their functions, but even more important will be their use in those products where utility and good looks go hand in hand to give America its high standard of living and working conditions.

In the industrial world, where studies have shown that the proper use of color helps production by improving visibility and thus increasing output, plastics in optimum colors and correct finishes will form such machine tool parts as instrument panels, instruction plates, dials, operating wheels, handles and buttons. Tubing and other insulation will come in identifying colors to facilitate tracing of circuits for repair work. More hand tools will be made with housings and handles of bright-colored plastics because it has been found that, in addition to their sales appeal, their added attractiveness assures them of better care.

The place of colored plastics in postwar transportation has been the subject of so much exaggeration and wishful thinking that any reasonable appraisal of their rôle seems pessimistic by comparison. Discarding all plastic helicopters and motorcars, there will still be plenty of room for plastics in the air, at sea, and on the roads and rails. Instrument panels, dials and knobs, door handles, steering wheels, horn buttons, radio housings, interior trim, light-

4—Color in dials and pointers is for identification, not looks. Colored insulating material (lower center) distinguishes shipboard cables. 5—In goggles and windshield cover, functional color helps to train pilots for blind flying



ing fixtures, upholstery and curtains, various items of tableware and kitchen equipment, window blinds and fittings for lavatories and dressing rooms are a few examples of the colored plastic products that will brighten the traveler's journey when he is again able to fare forth from home. Competition among the carriers for the privilege and profit of transporting all those who yearn to travel will mean added luxury in the equipment of passenger planes, ocean liners, railroads and buses. The harmonious color effects that can be achieved by the use of lightweight plastic materials should increase the demand for them in this expanding field.

Figures quoted for volume of peacetime construction, like those for motor car manufacture, are daily growing more extravagant. And, according to the findings of a variety of surveys on the subject, those citizens who do not expect to build or buy homes are planning to do over those they already have from attic to cellar. Whether the decorative scheme is to be Early American, Modern, Mexican or Main Street, the tendency, as expressed in answers to questionnaires, is all in the direction of light, labor-saving, and bright, fresh color. Plastic materials, which lend themselves to the reproduction of all known periods of styling and offer opportunities for new creative design, will have much that is colorful to contribute to every room in the house, beginning with such structural components as translucent pastel blocks for interior walls, and ending with useless but charming little colored animals for the shelf in the game room.

When the housewife turns to plastics for the color in her home, she learns that curtain fabrics woven of extruded plastic can be found to harmonize with the off-shade of the library rug. A plastic lamp base, a small radio cabinet, a cigarette box, some book ends, will carry an exciting note of Chinese red around the too-decorous living room. Shower head, faucet handles, towel bars, soap and tissue holders, molded in soft, powder blue pastel, will match the bathroom towels and rug and the plastic shower curtain.

6—Four varieties of plastic material in harmonizing tones create a cool, restful atmosphere for clients of the Tourneur make-up salon designed by Morris Sanders. 7—Curtain and upholstery fabrics woven of extruded vinylidene chloride come in a multitude of colors and designs. 8—Motor bus seats of the same material in a decorative plaid design can be washed with soap and water. 9—Buttons and buckles of urea will match any costume the couturières can dream up

COLOR PLATE, COURTESY CARBIDE & CARBON CHEMICALS CORP.

Cool greens and whites will give a clean, fresh look to her kitchen and keep it bearable on hot days. Sink, refrigerator, counter edging and trim, hardware, electrical appliances, handles for utensils, and scores of small wares all come in smooth-surfaced colored plastic, easy to take care of. In the nursery, the baby can chew safely on his colored plastic toys and eat his supper from non-shatterable plastic dishes, specially decorated to keep him amused.

These are, of course, only a few examples of the colored plastic articles which will be available for those who want to live cheerfully in the modern manner. The complete list is longer than the inventory of special shades in which plastic materials can be formulated—and one manufacturer offers 2000 in acetate alone.

On the more personal side, plastics will provide a shade to meet the every whim of the color-conscious. Dress fabric, costume jewelry, belt and buckle, buttons, slide fastener, hat and shoe ornaments, purse, compact, lipstick container and sun glasses of the complete synthetic manikin will all be contrived in harmonizing or contrasting shades of plastic material. She can even have a plastic wig to match her costume if such should prove to be a popular postwar fashion note!

#### Ask the men who own them

Excerpts from opinions advanced by the men who make plastic materials, those who mold, laminate and fabricate them, and those who design the products reflect the variety of angles from which the restoration of color may be viewed. For example:

- ¶ The phenolics will follow the trend toward color by increasing their proportion of colored resins.
- ¶ Research being done on new and modified colorants will result in the development of new faster-to-light coloring agents for plastics.
- ¶ Despite their good functional performance, their color range will always give plastics their main opportunities in the decorative field.
- ¶ Cosmetics containers and closures, which come in the



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7 COLOR PLATES, COURTESY FIRESTONE RUBBER & LATEX PRODUCTS CO.

special shades identified with a particular line of products, are naturals for plastics.

¶ Pretesting—bringing out a few items and seeing which sells best—could be applied to colored plastic products with advantage.

¶ Wide extrusions of thermoplastic material make colored baseboards a possibility.

¶ Women now dispense 80 percent of the national income, and changing feminine color fashions should be watched carefully by manufacturers of plastic products.

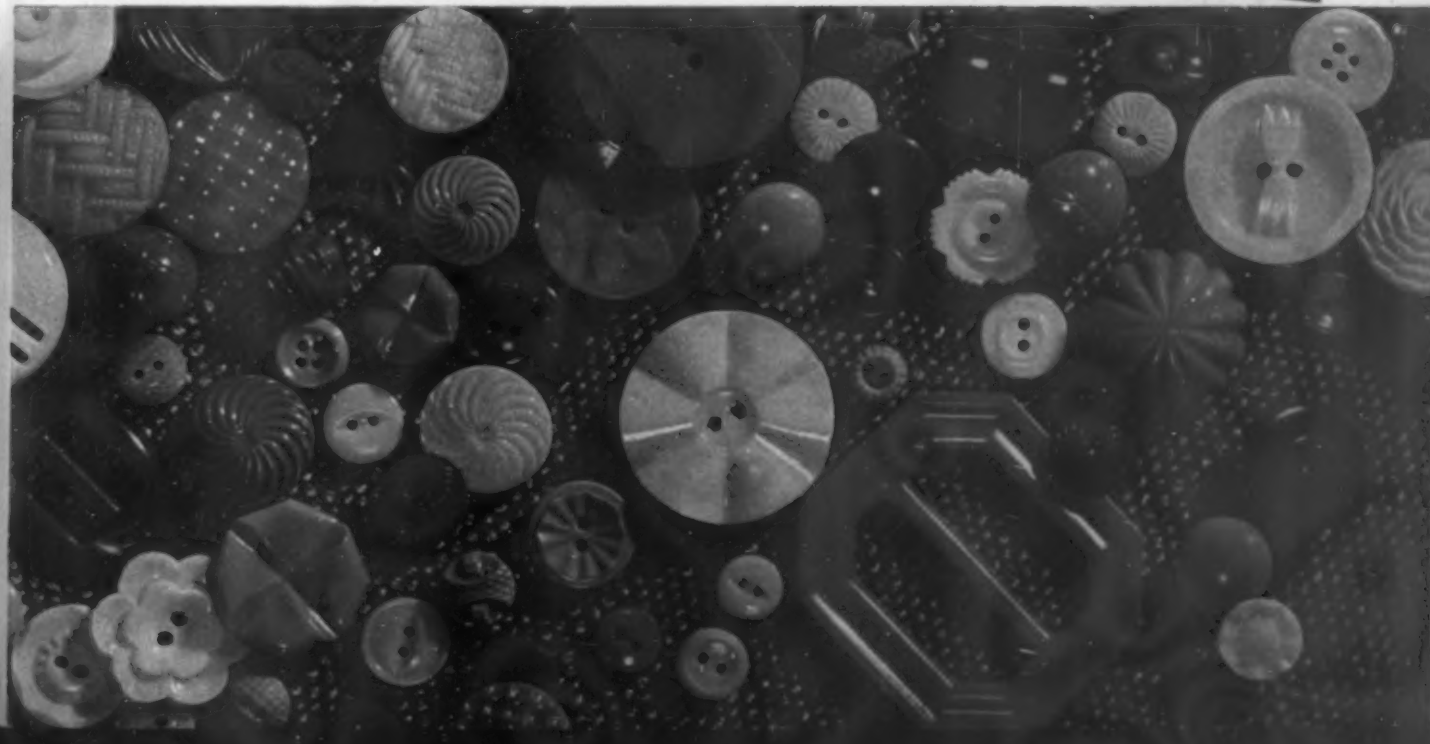
¶ The first postwar items in plastics will largely be duplicates of prewar models. A change of color or the application of color where none was used before will make them seem like new products.

¶ The industrial designers who work with plastics feel that their variety of color will do much to promote their wide acceptance after the war. Says Norman Bel Geddes:

"It is quite possible that many rooms in tomorrow's homes may be entirely built and furnished with plastics. Unlike wood and metal, plastics are not arbitrarily limited to specific colors. The color range is limitless. Since both



9 COLOR PLATE, COURTESY PLASKON DIV., LIBBEY-OWENS-FORD GLASS CO.



their color and finish are inherent, they will increasingly replace traditional materials where strength, flexibility and resistance to chipping, scarring and scratching are desirable."

From the point of view of adaptability of plastics to combination with other materials, Peter Muller-Munk thinks that "the use of plastics and their integral color, in combination with the new light yet strong metals, should help to stimulate buying and selling of postwar products."

Montgomery Ferar feels that the wise use of colored plastic materials will contribute to the achievement of harmony in decoration. According to Mr. Ferar, "plastics, by virtue of their integral color, will play a great part in dramatizing home appliances without clashing with established color schemes."

10

On the other hand, that plastics can be—and have been—wrongly used is recognized by Morris Sanders when he says:

"This embarrassment of riches can and frequently does

11

10—A sun porch grouping by Morris Sanders suggests some of the opportunities for color harmony inherent in plastics. Materials include low-pressure molded resin-bonded veneers, plastic filament textiles, phenolic and urea laminates, molded acrylic, molded and extruded acetate.

11—The case for a radio-phonograph-television unit is designed by Sundberg-Ferar to be molded by low pressure. Transparent and translucent plastics form grille and dial housings

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12—Eschewing the fanciful, Raymond Loewy designs a motor car in which colored plastics form fittings, upholstery and interior trim. 13—Peter Muller-Munk's colorful cash register is housed in ethyl cellulose. 14—The same designer covers plywood with woven vinylidene chloride to create attractive, lightweight luggage. Plastic hangers and transparent drawer fronts are features

13



prove a pitfall for designers and merchandisers. Because plastics are so colorful and versatile, especial care should be taken, especial judgment used. All colors are good colors—when in harmony with their surroundings.

¶ There is some divergence of opinion throughout the industry on the subject of standardization of color. Some members feel that specialization in a few basic colors has advantages from the manufacturing angle.\* One firm notes that those who have stuck to a selected few seem to market their products just as successfully as those who leap from shade to shade.

One member of the industry declares that standardization of color will help the materials manufacturer to turn out a better product at a lower price, enable the molder

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15—Designed by Peter Muller-Munk, an impact resistant phenolic padlock housing molded in two halves. 16—By the same designer, a trim two-toned postal or kitchen scale housing in urea or melamine. Transparent plastic sheeting magnifies scale. 17—Egmont Arens designs a lightweight boat molded of red and white phenolic sisal

17

to buy specific colors in quantities, and allow the distributor and dealer to cut down the number of items they are forced to stock in order that the housewife can get her percolator handle, mixmaster and cabinet hardware in the same shade of green.

One molder, who recalled with some acerbity that he once had 13 different shades of ivory on hand at one time, thinks that if materials men were to standardize a reasonable number of colors and make a price concession on them, meanwhile placing a heavy surtax on special colors, it would go a long way toward discouraging designers' taste for the exotic.

Those in favor of continuing to manufacture plastic products in a wide color range recall that past attempts to standardize color in other fields have not been particularly successful. One molder points out that even the U. S. Government couldn't do it, as witness the varying shades of olive drab in G. I. equipment. Another molder believes that as postwar competition increases, buyers will grow choosy and demand more striking colors and color combinations. The plastics industry, he thinks, should capitalize on this tendency to the greatest possible extent.

A great many men in the industry feel that efforts to standardize color will, as one of them puts it, "reduce interest in the materials and be injurious to the industry at large." One man recollects that an effort to establish a standard red for kitchen equipment came to naught when it was discovered that, although most people like red, they don't all like the same shade. The feelings of the anti-standardization group are best summed up by the member who says that the postwar consumer scramble for colors that no one else has used, though it will not make for easy manufacture in the plastics industry, nevertheless will "give us again the right for which we are fighting—the right to be individual."

#### Acknowledgments

Special thanks are due the designers who allowed us to reproduce their renderings, and the companies who lent color plates or articles to be photographed. For the statistics quoted, we are indebted to the materials manufacturers who so kindly supplied them. Men in all branches of the industry generously met our request for facts and opinions upon which to base this article, and we are most grateful for the time they took, the interest they showed, and the courtesies they extended.

PHOTO, COURTESY COLUMBIAN ROPE CO.





PHOTO, COURTESY U. S. ARMY AIR FORCES, WRIGHT FIELD

*Brig. General F. O. Carroll inspecting the first BT-15 airplane to employ glass fibers in sandwich construction for such structural parts as the rear section of the fuselage, the tail cone and side panels*

## Development of glass-reinforced low-pressure plastics for aircraft

by COLONEL PAUL H. KEMMER\*

MODERN PLASTICS is proud to present in the following group of articles the first detailed account of the application of low-pressure glass fiber laminates to aircraft. The number of pages we have devoted to this single subject is indicative of the importance we attach to a development which, when it is no longer restricted to the military field, will be available for the manufacture of civilian products.

### Objectives for development of some non-metallic materials

1. The material should show promise production-wise and the set-up required for manufacturing should offer advantages. The heavy equipment, including dies, presses, hammers and other tools, required for the manufacture of modern metal aircraft is costly and somewhat restrictive as regards design changes in the model for which the plant is currently tooled-up and also as regards adaptability to the economic production of other types and sizes of aircraft. A structural plastic having design and serviceability characteristics equivalent to those of the metals used in aircraft construction would not be employed unless it offered some worth-while advantages. These advantages should be in the form of low-cost molds, ovens, tools and other fabrication equipment. A plant set-up with such tools and equipment should lend itself more readily to production changes than does the set-up for metal aircraft manufacture.

The retooling and plant modification involved in accommodating design changes in the production model, changes

in the production quantities, or a production shift to a different type and size of aircraft, should cost less in time, labor and materials than the parallel alteration necessary in the plant set-up for all-metal construction.

Sub-assemblies or assemblies with many of the required design features molded integrally should reduce the multitude of separate parts and operations involved in current manufacturing.

The foregoing comments indicate the importance of directing the development of structural plastic materials toward those with promise of forming and molding under low pressures with simple manufacturing technique having practical control limits and with other properties which facilitate fabrication.

2. Durability and serviceability must be satisfactory. Modern, high-performance aircraft must be ready for satisfactory operation in and through atmospheric conditions over any part of this earth's surface. Protection from the elements while the aircraft are not in flight should not be contemplated. Resistance to deterioration under all service conditions must be high. Materials requiring close, frequent and skilled inspection and maintenance in any likely theater of operation are not satisfactory. Hygroscopic materials are expected to deteriorate rapidly in some locations. Exposure to weathering with extremes in temperature and humidity, that is, to the atmospheric conditions modern aircraft must endure, would cause hygroscopic materials to check, to deteriorate and to be highly questionable as regards strength or aerodynamic shape. Therefore, in the

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development of plastic materials suitable for aircraft construction, every effort must be directed to obtain satisfactory properties such as resistance to absorption of moisture and other fluids likely to be encountered, resistance to erosion or wear by the elements, durability and serviceability in any theater of operation.

3. The physical characteristics must be such that, with proper design and construction, the resulting structural efficiencies will compare favorably with those attending the proper use of aircraft metals. Materials must be nearly isotropic. If they are not isotropic, their application to airframe construction will be very limited.

Under normal loading conditions, the stresses in the directions of the principal axes of the structural components of the airplane bear a predictable relationship. However, under the severe loading conditions applied to efficient, modern aircraft, the stresses in the directions of the principal axes of some of these structural components increase without regard to the proportional relationship of the stresses in them for the normal loading conditions. Therefore, non-metallic materials for efficient aircraft structures should meet isotropic requirements.

Static strength alone is not sufficient. Impact and fatigue strength must be satisfactory. The endurance limit must compare favorably with that of acceptable metals. Creep values for all service and storage temperatures should be reasonably close to the creep values for materials which have already proved satisfactory in extensive operation.

Interest in the development of non-metallic materials should be directed to those combinations promising properties equivalent to those of the best alloys. The resin might be visualized as the more ductile portions and the reinforcing elements—such as high-strength glass fibers—as the hard, high-strength portions in such materials, thus making their structure somewhat analogous to that of some metals for aeronautical construction.

These low-density materials, by their section properties, their section moduli, should prove advantageous, both structurally and aerodynamically.

The relative importance of some of these objectives varies for different types of airplanes. Low-performance craft and trainers, for instance, might emphasize materials and processes conducive to low cost and ease of production rather than to high structural efficiency and universal serviceability. However, all objectives are important for military and efficient commercial aircraft.

### Planning the development

A study of the available reinforcing materials in connection with these objectives pointed to the development of various combinations of glass fiber and resins as offering considerable promise of success. Glass fiber was envisioned as the basic element, the foundation for this scope of the development of plastic materials suitable for aircraft construction. While the resins are no less important in any combination than the reinforcement, the advisability of having the specialists on glass fiber head up and coordinate this development is evident. Complete knowledge of the properties of glass fiber,



COL. PAUL H. KEMMER

its potentialities and weaknesses, the detailed processes in fabrication, the techniques and the all-around know-how of glass fiber are prerequisites. Of course, the success of the whole development project would depend upon the full cooperation of the resin manufacturers.

With purpose and background substantially as described in the preceding paragraphs, there appeared to be good cause to initiate a pertinent development project involving resins and glass fiber.

Consequently, on April 28, 1943, the Materiel Command of the United States Army Air Forces entered into a contract with Owens-Corning Fiberglas Corp. for the purpose of developing techniques for the fabrication of glass-reinforced, low-pres-

sure plastics potentially suitable for the construction of structural aircraft parts. An objective was to discover how to take full advantage of the inherent strength of glass fibers.

This corporation, in turn, contracted with each of seven resin manufacturers to provide one or more thermosetting resins considered best adapted for combination with glass reinforcements. The resin manufacturers were: Pittsburgh Plate Glass Co. (Columbia Chemical Div.), American Cyanamid Co., Libbey-Owens-Ford Glass Co. (Plaskon Div.), Dow Chemical Co., Monsanto Chemical Co., Bakelite Corp. and Marco Chemicals, Inc.

While this plastics development project was initiated primarily for its contribution to aeronautics, its results unquestionably will influence development in many other fields including the automotive, marine and building.

Glass was the common denominator to be used in combination with all the resins, so Owens-Corning coordinated all the research activities in its laboratories at Newark, Ohio. A specific function of the laboratories was further to explore the physical properties of glass fibers, develop methods of utilizing the properties and determine the properties of glass and resin combinations suitable for structural applications.

For reasons of national security, all information about the nature, scope and results of this research program has been restricted to those participating in it. Part of the veil of secrecy is now being lifted in the hope that the new data and advanced techniques to be revealed will be intelligently applied to production for military use and postwar civilian use, by manufacturers and fabricators in appropriate fields.

### Needed for structural applications

Some plastics—including glass-reinforced plastics—have found wide use in aircraft, although chiefly in non-structural applications. It is known that the Army Air Forces and part of the aviation industry have sought a high-strength, lightweight material that can be molded into intricate shapes without high pressures, high temperatures or expensive molds, and that can be used for structural or non-structural parts.

It has long been apparent that low-pressure, reinforced laminates<sup>1</sup> offered good promise of providing such a material. In place of expensive molds and presses, molds fashioned from wood, plastic, cement, plaster of Paris or cast metal can be

<sup>1</sup> The word "laminates" as used in this article is intended to suggest high-strength properties not only in the directions parallel to the planes of the laminations, but also normal to the planes of the laminations where the inference exists that such laminates are structurally satisfactory.

used, applying pressure by the rubber-bag method, using air, water, steam or other means.

### Engineering data supplied

Sufficient factual engineering data and knowledge of fabricating techniques to make reinforced plastics with a balance of high-tensile strengths, compressive strengths and other mechanical properties have not been available. In this research, short, fine glass fibers<sup>2</sup> have been used to obtain improvement in inter-laminar strength, and the firm glass and resin adhesion required to obtain high compressive strength in the glass fibers has been achieved.

Such data are needed in order to use glass and resin combinations most effectively for structural parts. The data resulting from the Air-Forces-sponsored research program conducted during the past year by the Fiberglas laboratories satisfy preliminary needs and should contribute materially to expedite the development of improved structural plastics and their successful application in aircraft production.

The resin manufacturers furnished some 18 low-pressure, thermosetting resins. The laboratories combined these resins with short, fine glass fibers (called flock fibers) and heat-treated glass cloth.

The resins used in some of the glass-fiber resin combinations for which results have been reported, are: Plaskon 900 (Plaskon Div., Libbey-Owens-Ford Glass Co.), Laminac P-4122 (American Cyanamid Co.), CR-39 and CR-39 Bd (Columbia Chemical Div., Pittsburgh Plate Glass Co.), Monsanto 38691 (Monsanto Chemical Co.) and MR-1A (Marco Chemicals, Inc.).

Results have also been reported for Plaskon 900 combined with ECC-11-112 heat-treated glass cloth, cross-laminated, with the flock fibers omitted; and for CR-149 (Columbia Chemical Div., Pittsburgh Plate Glass Co.) with OC-64 heat-treated glass cloth, with the flock fibers omitted.

The flock fibers—with diameters of approximately 5 one-hundred-thousandths of an inch—were dispersed in the resins to give increased inter-laminar strength. Best strengths were obtained with a quantity of fiber equal to 3 percent of the resin by weight. This, however, applies only to use with the OC-64 cloth. The amount of flock fibers to be used with other cloths would vary with openness of weave.

<sup>2</sup> Fiberglas flock.

Each of the combinations of resin and glass fiber was prepared in the form of cross-laminated sheets in 1/4- and 1/8-in. thicknesses. The sheets, approximately 13 in. square, were cured at 15 p.s.i. pressure between plates of glass in an electrically heated hot-air oven with internal circulation. Specimens were cut from the cured sheets, and were machined and tested. Specific gravities varied from 1.69 to 1.81.

Tensile strengths were found to be proportional to the amount of glass present in the laminates, and varied from 43,360 to 54,720 p.s.i. In the transverse and 45° directions, the tensile strengths were approximately 90 percent and 40 percent, respectively, of these longitudinal strengths. The tensile modulus values varied from  $2.00 \times 10^6$  to  $2.49 \times 10^6$  p.s.i.

Values for edgewise compression obtained on the 1/4-in. sheets varied from 36,570 to 56,820 p.s.i. The results on 1/8-in. sheets varied from 33,270 to 37,760 p.s.i. The lower strength values for the 1/8-in. sheets were probably the result of improper cure of the latter.

### Flexural values

Flexural values were higher than either tension or compression values, the lowest flexural value being 45,350 p.s.i. and the highest 84,600 p.s.i. It is assumed that this is due to calculating the stresses according to simple beam formulae, when actually the neutral axis is not at the center of the section.

The flexural modulus ranged from  $2.32 \times 10^6$  to  $2.98 \times 10^6$  p.s.i. The proportional limit in flexure ranged from 15,710 to 32,250 p.s.i.

### Other properties

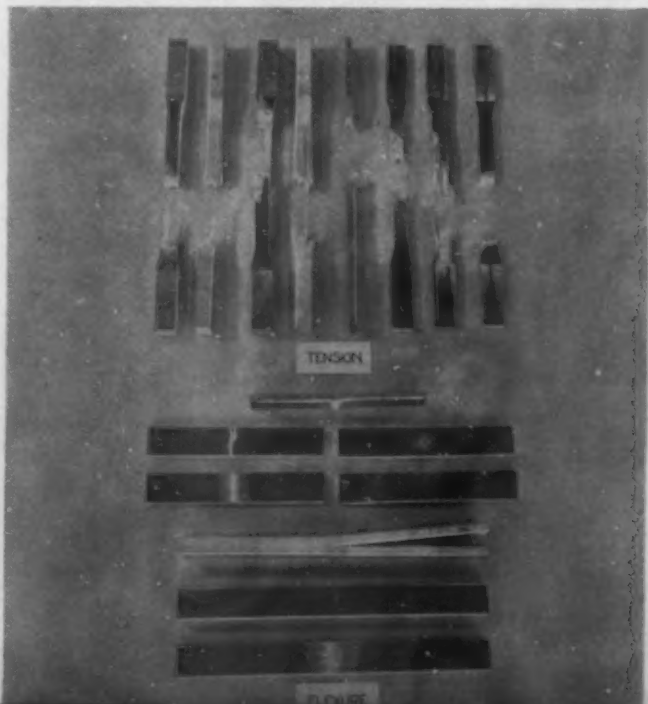
Hardness values varied from 110 to 119 on the Rockwell M scale.

Longitudinal shear strengths from 6350 to 14,380 p.s.i. were obtained. The transverse shear strengths were approximately 105 per cent of the longitudinal strengths.

Impact values ranged from 24.87 to 31.46 ft.-lb. per in. of notch for longitudinal samples notched on the face. Samples notched on the edge gave values from 10.79 to 32.03 ft.-lb. per in. of notch. Unnotched samples gave results ranging from 28.82 to 31.25 foot-pounds. These results show clearly

1 and 2—Specimens of glass-cloth laminates after they have been subjected to various tests

1 PHOTOS, COURTESY OWENS-CORNING FIBERGLAS CORP.



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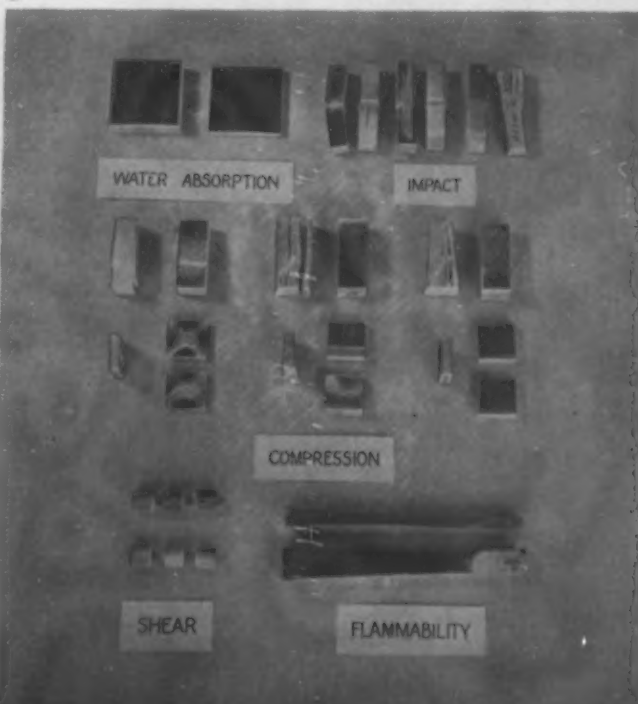
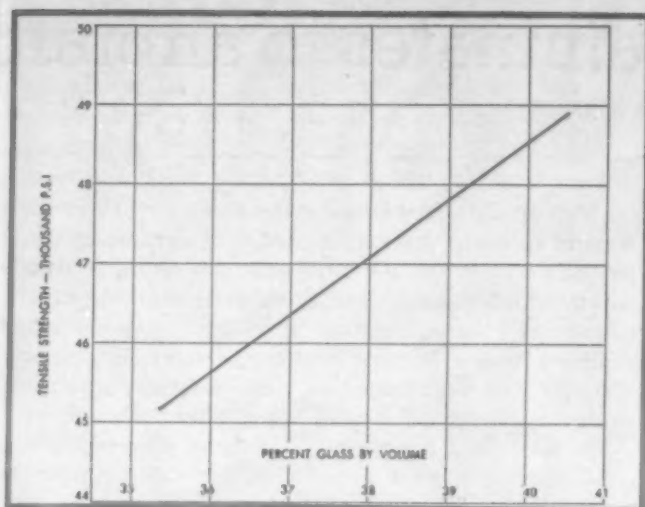


TABLE I.—AVERAGE PROPERTIES<sup>a</sup>—SHEETS, NOMINAL THICKNESS, 1/4 IN.

Property	Direction of load	Resin A OC-64 cloth	Resin B OC-64 cloth	Resin C OC-64 cloth	Resin D OC-64 cloth	Resin E OC-64 cloth	Resin F OC-64 cloth	Resin G <sup>b</sup> OC-64 cloth	Resin H <sup>b</sup> ECC-11-112 cloth
Tension, p.s.i.	Longitudinal Transverse 45°	50,730 39,900 13,690	47,720 42,820 14,000	48,560 44,120 19,140	44,910 39,750 13,730	46,270 42,580 14,810	46,400 43,960 14,390	54,720 45,740 19,570	43,360 43,060 * 24,370
Compression, p.s.i.	Longitudinal Transverse 45°	43,230 31,680 16,300	40,540 40,740 17,490	48,000 41,620 20,400	40,410 46,540 21,110	51,030 47,160 17,740	46,670 44,540 16,830	54,180 56,820 27,930	36,570 39,520 23,400
Flexure, p.s.i.	Longitudinal Transverse 45°	63,150 48,100 26,500	61,900 59,000 28,350	61,150 49,700 33,850	62,500 55,300 29,150	72,500 65,650 26,850	71,150 63,750 27,900	84,600 62,600 40,920	45,350 50,700 34,880
Modulus of elasticity, p.s.i.	In tension	2.33 × 10 <sup>6</sup> 1.86 × 10 <sup>6</sup>	2.24 × 10 <sup>6</sup> 2.02 × 10 <sup>6</sup>	2.27 × 10 <sup>6</sup> 2.05 × 10 <sup>6</sup>	2.00 × 10 <sup>6</sup> 1.83 × 10 <sup>6</sup>	2.16 × 10 <sup>6</sup> 1.98 × 10 <sup>6</sup>	2.10 × 10 <sup>6</sup> 2.00 × 10 <sup>6</sup>	2.49 × 10 <sup>6</sup> 2.13 × 10 <sup>6</sup>	2.18 × 10 <sup>6</sup> 2.19 × 10 <sup>6</sup>
In flexure	Longitudinal Transverse 45°	2.97 × 10 <sup>6</sup> 2.27 × 10 <sup>6</sup> 1.05 × 10 <sup>6</sup>	2.64 × 10 <sup>6</sup> 2.11 × 10 <sup>6</sup> 0.95 × 10 <sup>6</sup>	2.51 × 10 <sup>6</sup> 1.89 × 10 <sup>6</sup> 0.79 × 10 <sup>6</sup>	2.64 × 10 <sup>6</sup> 1.79 × 10 <sup>6</sup> 0.97 × 10 <sup>6</sup>	2.71 × 10 <sup>6</sup> 2.19 × 10 <sup>6</sup> 1.13 × 10 <sup>6</sup>	2.67 × 10 <sup>6</sup> 1.82 × 10 <sup>6</sup> 0.78 × 10 <sup>6</sup>	2.98 × 10 <sup>6</sup> 2.34 × 10 <sup>6</sup> 1.36 × 10 <sup>6</sup>	2.32 × 10 <sup>6</sup> 2.45 × 10 <sup>6</sup> 0.26 × 10 <sup>6</sup>
Proportional limit, p.s.i.	Longitudinal Transverse 45°	24,500 15,400 5,730	23,800 11,300 6,800	31,000 18,400 6,000	23,800 24,500 4,660	15,710 15,760 18,750	28,600 15,900 9,600	32,250 21,100 15,100	10,500
Coeff. thermal exp., cm./cm./°F.	Longitudinal Transverse	6.9 × 10 <sup>-6</sup>	5.1 × 10 <sup>-6</sup> 7.4 × 10 <sup>-6</sup>	8.6 × 10 <sup>-6</sup> 9.7 × 10 <sup>-6</sup>	6.6 × 10 <sup>-6</sup> 9.0 × 10 <sup>-6</sup>	7.7 × 10 <sup>-6</sup> 9.7 × 10 <sup>-6</sup>	7.8 × 10 <sup>-6</sup> 8.5 × 10 <sup>-6</sup>	8.2 × 10 <sup>-6</sup> 8.9 × 10 <sup>-6</sup>	8.5 × 10 <sup>-6</sup> 7.3 × 10 <sup>-6</sup>
Water absorption, %	...	0.6	0.3	0.4	0.6	0.3	0.5	0.4	
Hardness, Rockwell M	...	110	111	110	115	115	112	117	119
Chemical resistance, %	...								
Aviation gasoline, weight increase	...	-0.1	0.0	-0.1	-0.1	0.0	-0.2	1.23	
Prestone, weight increase	...	-1.9	0.0	0.0	0.1	0.1	-0.1	0.77	
Flammability, burning rate, in. per min.	...	Self-extin- guishing	0.247	0.271	Self-extin- guishing	0.251	Self-extin- guishing	0.4	Self-extin- guishing
Glass content, %	...	60.8	53.1	52.3	49.2	54.2	54.7	53.4	54.7
By weight	...	39.2	39.5	39.7	35.9	37.9	40.8	39.2	41.2
By volume	...								
Specific gravity	...	1.71	1.78	1.81	1.73	1.69	1.77	1.76	1.78

<sup>a</sup> The above properties have been determined by means of procedure outlined in L-P-406 Federal Standard Stock Catalog, Section IV, Part 5, "Federal Specification for Plastics, Organic; General Specifications (Met rod of Tests)." <sup>b</sup> Flaked fibers omitted.



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that glass-reinforced laminates have high impact resistance.

Thermal expansion values in the longitudinal direction varied from  $5.1 \times 10^{-6}$  cm. per cm. per  $^{\circ}$ F. to  $8.6 \times 10^{-6}$  cm. per cm. per  $^{\circ}$ F. In the transverse direction the values were higher, ranging from  $7.3 \times 10^{-6}$  cm. per cm. per  $^{\circ}$ F. to  $9.7 \times 10^{-6}$  cm. per cm. per  $^{\circ}$ F. The rates of expansion were found in some cases to vary with temperature.

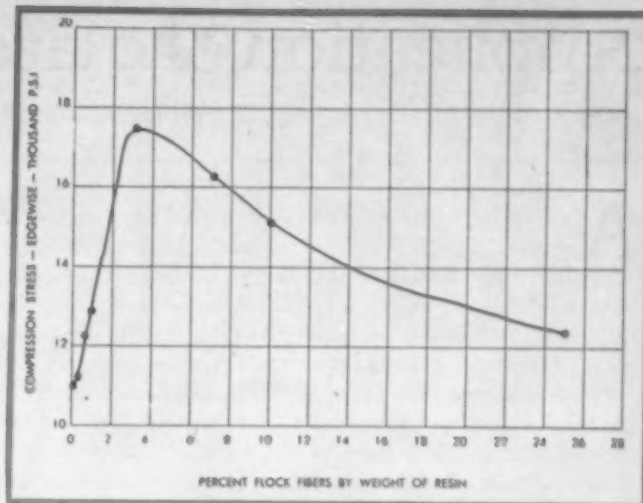
Flammability tests gave results from self-extinguishing to combustion at the rate of 0.4 in. per minute, depending to a great extent upon the resin.

Moisture absorption values from 0.6 to 0.3 percent gain in weight were obtained. In general, the laminates tested had better absorption resistance to aviation gasoline and Prestone than they had to water. The gains in weight varied from 0 to 1.9 percent.

### Possibly a balanced material

This research project has yielded information which shows that some of the important mechanical properties of the fiber glass-reinforced, low-pressure laminates, on the basis of strength to weight ratio, are equal to or higher than those properties of some of the alloys now used in aircraft structures. It indicates also the means by which these materials can be given adequate strength normal to the planes of the laminations.

During the past year, tensile strength values of glass-reinforced laminates higher than the values given in this paper have been published. But structural members subjected to tension loads only are seldom to be found in modern



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airplanes. Most members in aircraft structures must be efficient in the transmission of compression and shear loads, as well as of tension loads. A material having one or two excessively high properties, while its other properties are relatively very low, cannot be considered suitable for aircraft construction. A material having balanced mechanical properties is a prerequisite for structural efficiency.

Based on the results of limited investigations, some of the laminates developed in this research appear to be adequately balanced for some applications. It also appears that the ingredients and processes involved, permit of such flexibility in the product that its balance might be readily adjusted where improvement is dictated.

### Present status

The material is still in the laboratory stage so far as aircraft structural applications are concerned. Not all the resins tested are now available in commercial quantities. The techniques employed in fabricating the laminates are of great importance in securing the desired physical properties, and they are still laboratory techniques. They must be tried out in experimental departments or pilot-plant operations before they can be applied to factory production.

However, this research on glass fiber-resin low-pressure laminates has made available essential experimental data and other information which should serve well 1) for an initial evaluation of the potentialities of a promising construction material, 2) as a foundation for planning future development and 3) in starting an experimental group.

3—Graph showing effects of varying amounts of flock fibers on compressive strength of a typical laminate of un-heat-treated glass cloth. 4—Relation of tensile strength to the percentage of glass fiber in typical laminates. 5—An indicating method used to measure the flexural strength and modulus of elasticity of a test specimen of laminate. 6—Impact test on typical glass-reinforced laminate. Notice the delamination

5 PHOTO, COURTESY OWENS-CORNING FIBERGLAS CORP.



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# Application of glass laminates to aircraft

by CAPT. GEORGE B. RHEINFRANK, JR., and LIEUT. WAYNE A. NORMAN\*

**A**N airplane fuselage constructed of glass fiber laminated with a newly developed contact resin was recently built and flight tested at the A.A.F. Materiel Command, Wright Field, Dayton, Ohio. This fuselage, the first successful laminated plastic aircraft primary structure, proved stronger for its weight than the standard metal section.

For several years the Army Air Forces has been accumulating data which have indicated that reinforced, low-pressure plastics offer great promise in the construction of primary structural parts for aircraft. Use of plastic laminates had previously been restricted to non-structural parts such as fairings, fillets and doors, because physical properties were not adequate for primary structures. Developments in the use of high-strength fibers in combination with synthetic resins, however, appeared to open an entirely new field for laminates having adequate strength for primary structures.

Many different types of fibers, including cotton, linen, rayon, silk and glass fibers, have been used as reinforcing agents in plastic laminates. Several factors led to the selection of glass fiber as the most satisfactory reinforcing material. The strength-weight ratio of the glass fibers is substantially greater than that of the other fibers. The glass fibers can be produced in continuous filaments and their properties can be closely controlled, making possible a uniform laminate. The impact resistance is high, and the moisture absorption low. It appeared therefore that a laminate could be made using fiber glass which would be light, strong and uniform, and would have satisfactory weathering characteristics.

The Materiel Command has had considerable experience with high-pressure type laminating resins. These resins did not lend themselves to molded aircraft production because

the high pressures and temperatures necessary to cure them required expensive and complicated equipment which would not be available for any large-scale production or readily adaptable to design changes. From this it was evident that a no-pressure, low-temperature thermosetting resin would eliminate these objections. This no-pressure resin must have adequate strength properties, low moisture absorption, weather resistance and dimensional stability.

The need for a new resin led to the development of the copolymer resins, which are fundamentally different from the well-known condensation-type resins such as urea-formaldehyde and phenol-formaldehyde, which give off gaseous by-products and water during curing. The new resins are copolymer polymerizing resins which cure without the elimination of by-products. This characteristic revolutionizes fabrication techniques, for, naturally, complicated and inflexible high-pressure equipment is unnecessary when no pressure is required to cure the resin. With copolymer resins, high-temperature cures, worry regarding "blisters," complicated equipment and paternal care are no longer requisite.

Because this new type of copolymer resin is a recent development, and there were no comparative data on the relative properties and characteristics of the different resins, a study was made of those available. In so far as physical properties are concerned, these resins proved to be uniformly good and were not significantly different. The handling characteristics and the uniformity in the finished laminates became the primary consideration in the selection of a resin.

Particular attention was paid to the following factors: the sensitivity of resin to variation in curing cycles as affecting physical properties of the finished laminates; the ability of the resin to be retained in the cloth during cure; spreading qualities; viscosity and tackiness; effect of inhibitors and

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*Col. P. H. Kemmer, Lieut. W. A. Norman and Capt. G. B. Rheinfrank, Jr., standing beside the BT-15 plane*

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presence of volatile or toxic materials. Considering the handling characteristics of the resins as adapted to the experimental equipment available at Wright Field, Plaskon 900 was selected as the most suitable for this application.

The copolymer resins as well as the fabricating techniques are constantly being modified and improved, and the optimum has certainly not been reached.

To prove the feasibility of the material and the process, the A.A.F. decided to fabricate at Wright Field some primary structural component of a plane which could be subjected to static tests and service tests in actual flight. Numerous applications were considered, such as outer wing panels, wing center sections, a fuselage, and stabilizer of fin assemblies.

The final selection—the rear section of the BT-15 airplane fuselage—was made for several reasons: 1) it is a fairly high-stressed part, which appeared necessary in order to keep within weight limitations; 2) it is also well adapted for monocoque construction, which was being considered; 3) the mold is of simple curvature, thus reducing the time necessary for its fabrication; 4) structure has relatively few cutouts, doors, etc., making for easier fabrication and unbroken surfaces.

### Sandwich construction selected

It then became necessary to decide what type of construction should be employed in making the fuselage. A number of considerations entered into the selection of a sandwich type of construction, incorporating a balsa-wood core between a thin inner and outer skin of glass-reinforced laminate. Sandwich-type structure is particularly adaptable to curved sections since its inherent rigidity permits elimination of a large portion of internal stiffening structure such as stringers and bulkheads. Also, the entire sandwich could be fabricated in one operation since the new bonding resin could simultaneously laminate the glass fibers and glue them to the core material without crushing the low-density core.

There are many types of glass cloth with different thicknesses and weaves commercially available, and it was necessary to select one which would produce a laminate of an isotropic nature and still stay within minimum gage requirements. For a laminate 0.030 in. in thickness, 10 plies of ECC-112 (0.003 in. in thickness) can be used in place of 3 plies of OC-64 (0.010 in. in thickness). By using the larger number of laminations a more isotropic material was obtainable. Also, Materiel Command tests indicated that strength properties of ECC-112 dropped approximately 30 percent at 45° when cross-laminated, while cross-laminated OC-64 dropped off as much as 60 percent.

### Glass-resin combination tested

Before actually constructing the fuselage, numerous tests were conducted to determine the physical characteristics of the glass-resin combination to be used. Directional property tests were made of the glass cloth laminated parallel (0°), at 12°, and at 45° to the longitudinal axis. It was concluded that the 12° laminate gave the most satisfactory directional properties for the loads to be encountered in the fuselage.

While the 45° laminate gave uniform directional properties,

1—While resin was applied here by a hand operation, in production a differential roll coater can be used. 2 and 3—The task of working out laps and wrinkles is facilitated by laying the impregnated cloth, which is limp and flexible, over the male form. 4—Before transfer to the female mold, the 5 plies that comprise the complete half of a fuselage skin are carefully trimmed



the longitudinal strength was not sufficiently high. Strength of the parallel laminate at  $45^\circ$  was considered too low. The  $12^\circ$  laminate was chosen as a practicable compromise, giving adequate strength both longitudinally and at  $45^\circ$ .

Additional tests indicated that a sandwich using 5 plies of the ECC-112 cloth for faces with balsa wood core having grain parallel to the faces was satisfactory. Repeated stress and weathering tests indicated that there would be no decrease in the strength of such a sandwich under service conditions.

#### Distribution of load

Since the fuselage which was to be constructed of a laminated plastic material would have to be attached to the con-

ventional steel tube construction of the airplane, it was necessary to choose between bolting or gluing as alternative methods of attaching the necessary fittings. Among other considerations it was essential to distribute the load equally between the two faces of the laminate. For this reason it was necessary to substitute at the fitting points a material whose density was higher than that of balsa. Spruce inserts were used in this application.

The Materiel Command for several years had been working with Cycleweld<sup>1</sup>—an adhesive which can be used to bond metal to laminated materials. Tests of various types of fittings showed that a Cyclewelded fitting resulted in the best distribution of load and permitted a light assembly. Vibration and weathering tests confirmed its suitability.

#### Fabrication of fuselage

Now we have at our disposal a new material which has both adequate physical properties for primary structures and outstanding new fabrication possibilities. The use of these new no-pressure resins in conjunction with glass fibers, which develop their maximum strength in the uncompressed condition, enables the fabricator to mold structures using no more pressure than is necessary to hold the fibers in place during curing. Molded parts can now be made by simply placing them in an oven and curing under vacuum pressure.

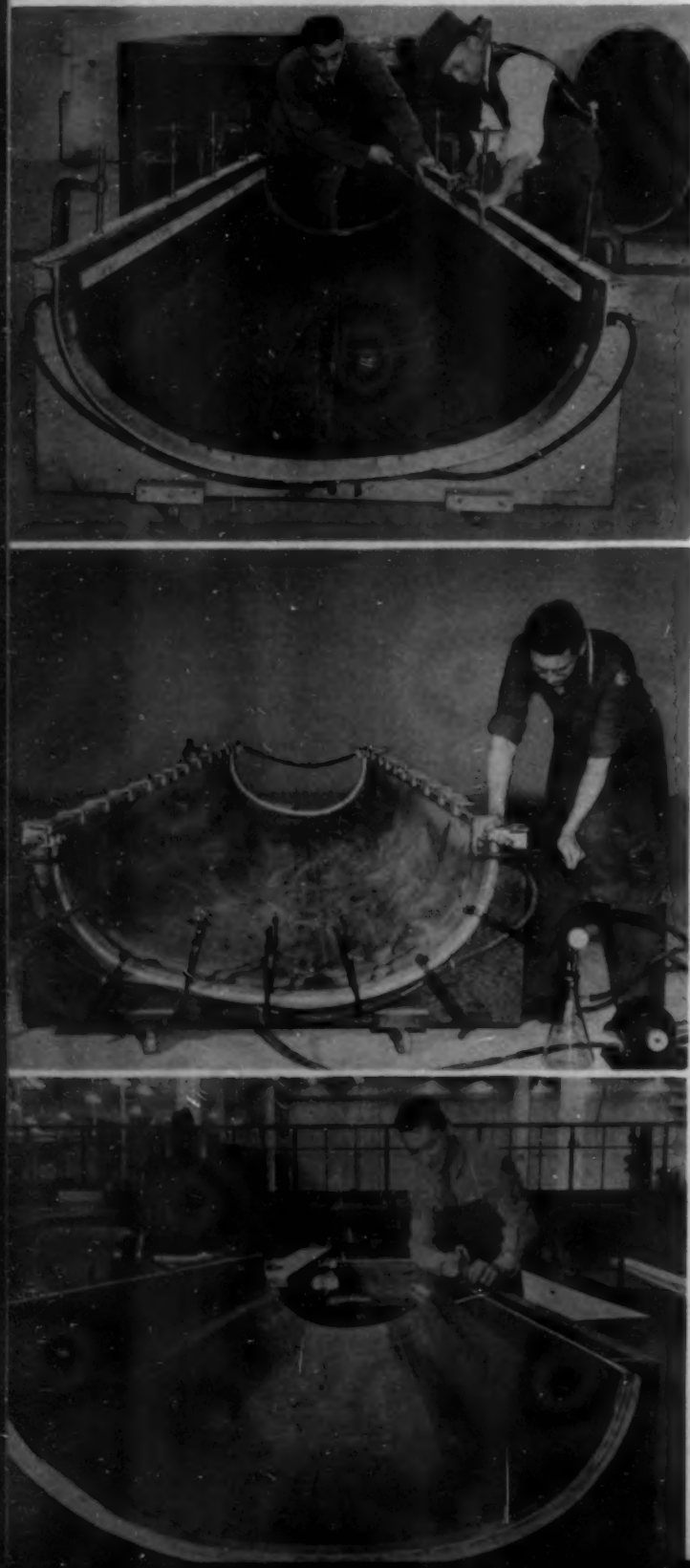
To take advantage of the opportunity to complete the sandwich in a single operation, it was necessary to apply heat and pressure to both faces of the sandwich simultaneously. The most practical way to apply heat was to use an oven. Pressure was applied by evacuating a rubber blanket in a female metal mold having the exact contours of the fuselage and made of  $1/4$ -in. soft aluminum formed over a brake.

Figure 1 shows the cloth being laid upon the impregnating table. The laminating resin was applied uniformly to the glass cloth by the use of squeegees. After each lamination was impregnated with the resin, the cloth was transferred to a male mandrel (Fig. 2) and the direction of the fibers in each successive ply was oriented alternately  $12^\circ$  left and right of the longitudinal axis of the fuselage. Figure 4 shows the trimming of the 5 plies which form the outer skin of the sandwich. These plies (shown in Fig. 3) were then ready to be transferred from the male mandrel to the female mold. The balsa core, which likewise had been prefabricated, was coated with resin and laid in its proper position. The 5 plies which made up the inner face were laid up on the male mandrel and transferred to the mold in a manner similar to that employed in transferring the outer plies (Fig. 5).

A rubber blanket was placed over this assembly and sealed on the edges with pressure seal. A vacuum was then drawn between the blanket and the mold, and care taken that the inserts were drawn into place (Fig. 6). Once this was done, the assembly was ready to be cured. The mold, which was mounted on wheels, was rolled into the oven where it was subjected to a temperature of  $220^\circ$  F. for a period of 3 hours. At the completion of the cure, the molded section was re-

<sup>1</sup> See "Cycleweld—a new bonding process," MODERN PLASTICS 21, 65-69; 152 (Sept. 1943)—Ed.

5—After the inner plies are dropped into place, the assembly is ready to be covered with a rubber blanket that subsequently will be sealed on all outside edges. 6—A small vacuum pump exhausts all the air from between the rubber blanket and the layup. 7—Prior to the insertion of a spline which serves to hold the 2 halves together, edges of the cooked sections are squared



moved from the mold and rough edges trimmed off (Fig. 7).

In order to join the two halves of the fuselage together, a spline was inserted into the core, and glued with a cold-setting resin glue. A glass-fiber gusset, made up similar to the outer and inner faces, was laminated over the spline (Fig. 8). Bulkheads were assembled and glued into place. The completed fuselage (Fig. 9) was then ready for assembly.

### Tail cone and side panels

To experiment with the fabrication of semi-monocoque structures, it was decided to make the tail cone and the side panels for the BT-15. The easiest way to make a mold for the tail cone was to use the metal tail cone as a mold, reinforcing it with sand to keep it from collapsing. Eleven plies of ECC-112 glass cloth were impregnated and assembled over the upper and lower halves of this mold. Tailored blankets were laid over the assembly and clamped airtight. A vacuum was then applied to the assemblies which were subsequently placed in the oven and cured for 2 hours. Figure 10 shows the tail cone ready for assembly on the fuselage.

The side panels were similar to the metal ones which they replaced. Flat sheets forming the outer skin were fabricated under vacuum pressure. The hat-section stiffeners were molded over the metal stiffeners on the standard side panel (Fig. 11). The side panels were then assembled by gluing the molded stiffeners to the flat sheet, and were then ready for assembly on the airplane.

### Fabricating advantages

It should be remembered that the fabrication of this fuselage was purely experimental and the methods used are not applicable directly to production. For example, with modified techniques the cure time will be reduced from a matter of hours to a very few minutes. The fabricating process will undoubtedly be further developed and improved, but the basic simplicity of the operation, its adaptability to a continuous process, and the minimum number of man-hours required, seem to offer great advantages to the commercial fabricator.

In addition to savings in fabrication time, this type construction appears to provide such further advantages as lessened air resistance, greater plane speed, less buffeting and vibration. Such results should logically follow the use of a strong, rigid, low-density material offering permanently smooth exterior surfaces uninterrupted by rivet heads or other surface defects.

It is known, for example, that loss of speed—as much as 23 miles an hr. in the case of certain pursuit planes—has been suffered when exterior surfaces have become roughened with use. Even flush riveting has not entirely overcome this handicap inherent in airplane surfaces fabricated of riveted sections.

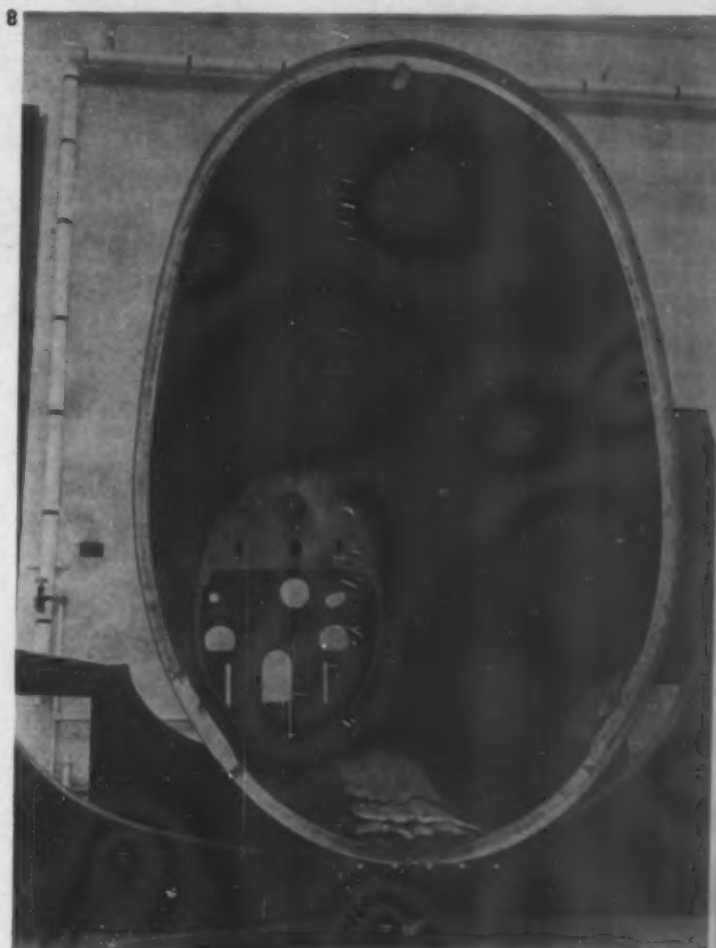
### Static tests of fuselage

To insure that the design and materials as incorporated in the plane will perform satisfactorily under all service and flight conditions, it is standard practice for the Materiel Command to carry out static tests simulating the stresses

the plane will encounter in actual use. Loads are applied hydraulically or by use of shot bags in the Static Test Laboratory at Wright Field. The sandwich fuselage satisfactorily supported 100 percent load, as required by Air Forces Specifications, under all conditions including the following:

- 90° tail-wheel load
- 45° tail-wheel load
- Vertical stabilizer load
- Jack pad vertical load
- Horizontal stabilizer front-spar load
- Maximum horizontal stabilizer load
- Tail-wheel side load

Subsequently, to determine ultimate strength of the fuse-



8—The outside glass-cloth splice plate, which holds the 2 halves of the fuselage together, is cured under heat and pressure. The fuselage rests on a steam-heated rubber blanket which supplies the heat while shot bags laid inside the fuselage supply the necessary pressure.  
9—One of the points at which the sandwich section is bolted to the forward fuselage is under inspection



10



11

10—This tail cone assembly indicates the adaptability of glass-cloth laminate to smooth-surfaced compound curvatures. 11—Side panel molds built of thin plywood sheets demonstrate the simplicity of the tooling process

lage, it was subjected to a destruction test under the most critical torsion condition, viz., tail-wheel side load tending to produce a torsional moment that would cause the fuselage to buckle. Failure occurred at 180 percent of design load by fracture of the fitting attachment bolt.

Since failure did not occur in the fuselage or fuselage fitting, it was possible to run additional load and vibration tests. All of the static tests exceeded the expectations of the A.A.F. Materiel Command engineering personnel and indicated the possibilities of future application.

#### Strength-weight ratio high

Destruction test of a metal fuselage of similar design weighing 70 lb. resulted in failure at 1550 lb. load, which was 108 percent of design load. A birch plywood fuselage weighing 86 lb. failed under a load of 1580 lb. or 110 percent of design load. The glass-reinforced sandwich fuselage weighed 78 lb. and took a load of 2590 lb., or 180 percent of its design load, before breakage of the fitting bolt.

The strength-weight ratio for the metal fuselage was 22, for the plywood fuselage 18 and for the glass-reinforced fuselage 33 as shown in Table I. This indicates that for equivalent weight the glass-reinforced sandwich fuselage would be considerably stronger than the metal or plywood fuselages. An indication of the increased aerodynamic efficiency made

possible is given by a comparison of Figs. 12 and 13 showing the metal and glass-reinforced fuselages under the same load.

#### Vibration and firing tests

The glass-reinforced fuselage was vibrated for 7,500,000 cycles under load. At the conclusion of this test, the fuselage satisfactorily supported the proof load and no deleterious effects were noted. It was observed that damping characteristics of the fuselage were excellent.

Firing tests were conducted to determine the ability of the fuselage to stand up under gun fire. Twenty-millimeter, high-explosive and 50-caliber machine gun shells were fired at the fuselage from various directions and angles. Performance of the fuselage was highly satisfactory under fire as would be expected, since similar laminates are currently used as backing panels for self-sealing gas tanks.

#### Comparison with aluminum

The most efficient application of a new material requires that the engineer properly evaluate all of its relative advantages and disadvantages as compared to materials in current usage. Of interest to the aircraft designer is the comparison of glass-cloth laminate with 24ST aluminum (Table II).

The advantages of glass-cloth laminate over 24ST aluminum as evident to date, are higher specific strengths in tension, compression and flexure; smoother fabricated surfaces; greater damping capacity; better insulating qualities, both thermal and acoustical; and possible fabrication advantages, as mentioned previously.

Properties that call for design ingenuity are lower specific modulus, lower percentage of elongation, directional considerations and lower bearing strength. An obvious solution to the latter problem, as encountered in the BT-15 fuselage, would be to glue on the fittings. Directional properties may be taken care of by orienting plies, such as the orientation of face plies in the BT-15 fuselage.

#### Recent progress substantial

Because of the substantial increase in values of physical properties attained during the last 9 months through the joint efforts of Owens-Corning Fiberglas Corp. and the

TABLE I.—STRENGTH-WEIGHT COMPARISON OF GLASS-CLOTH SANDWICH FUSELAGE FOR BT-13-BT-15 AIRPLANE (Tail wheel side load condition, 1440 lb.)

Type of structure	1 Weight of section lb.	2 Destruc- tion test load lb.	3 Destruction load in per- cent ulti- mate load	4 Strength- weight ratio (2) ÷ (1)
Glass cloth—balsa sandwich mono- coque	78	2590	180	33
Aluminum semi- monocoque	70	1550	108	22
Wood semi-mono- coque	86	1580	110	18

TABLE II.—COMPARATIVE SPECIFIC STRENGTHS OF CROSS-LAMINATED GLASS CLOTH AND ALUMINUM

Property	1 Typical glass-cloth laminate <sup>a</sup>	2 Specific strengths glass-cloth lam. <sup>b</sup>	3 Specific strengths 24ST aluminum <sup>b</sup>	4 Aluminum alloy 24ST sheet <sup>c</sup>	5 Specific value
Specific gravity, s.g.	1.75	1.75	2.77	2.77	...
Ultimate tensile strength, u.t.s.	47,400 p.s.i.	27,000	22,400	62,000 p.s.i.	u.t.s. s.g.
Ultimate compressive strength, u.c.s.	45,000 p.s.i.	25,700	22,400	62,000 p.s.i.	u.c.s. s.g.
Modulus of rupture, u.f.s.	65,400 p.s.i.	21,400	8100	62,000 p.s.i.	u.f.s. (s.g.) <sup>d</sup>
Modulus of elasticity (buckling) $E \times 10^6$	2.2 p.s.i.	0.41	0.495	10.5 p.s.i.	E (s.g.) <sup>d</sup>
Modulus of elasticity (deflection) $E \times 10^6$	2.2 p.s.i.	1.25	3.8	10.5 p.s.i.	E (s.g.)

<sup>a</sup> Average values of Owens-Corning Fiberglas Corp. Report No. 328 for cross-laminated OC-64 cloth with several types of resin.

<sup>b</sup> Specific values computed as shown in Column 5. Items 4 and 5 take into consideration the increased thickness allowable for equal weight sections of lower density material.

<sup>c</sup> ANC-5.

resin manufacturers, in cooperation with the Materiel Command, the use of glass-cloth laminate in primary aircraft structures has been proved possible.

As evident in items 2 and 3 of Table II, the specific tensile and compressive strengths of glass-cloth laminate are higher than those for standard 24ST aluminum. This condition indicates that direct stress sections such as spar flanges, where instability is not critical, can be used advantageously in aircraft structures. The specific modulus of rupture of glass cloth is higher than that of aluminum (item 4 of Table II).

Buckling strength of glass-cloth flat panels approaches that of aluminum panels for the same weight, as shown in item 5, Table II. Since the greater portion of primary aircraft structure is designed on compression allowables in the short-column range, the most critical properties of materials as applied to the design of semi-monocoque or sandwich structures are compressive yield strength and modulus of elasticity, which jointly determine the ultimate compressive load. Thus the combination of the high specific compressive strength with a modulus of elasticity satisfactory in specific buckling strength indicates that such panels will be comparable to aluminum structures in strength-weight ratio. Deflection of glass-cloth elements will be greater than that of aluminum sections of equivalent weight, as shown by Table II. It

must be noted that this comparison applies to stable sections.

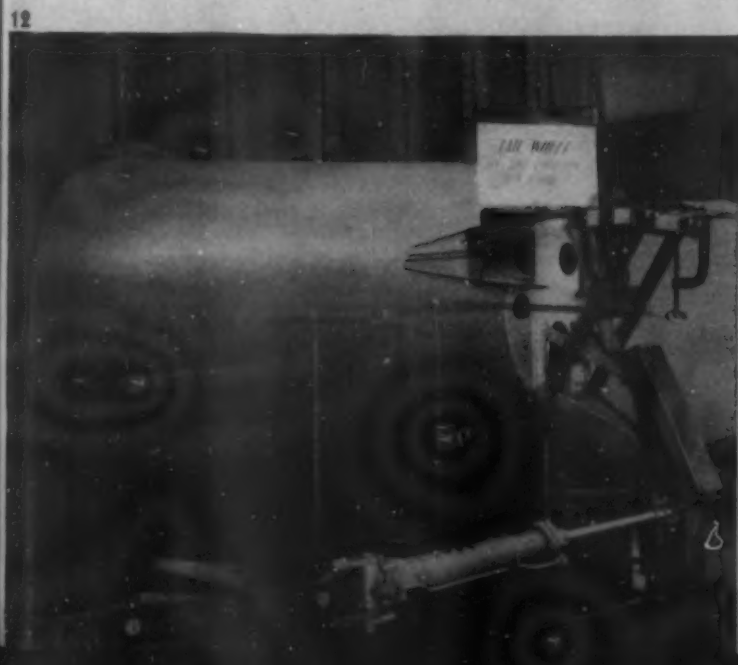
### Sandwich construction

Sandwich construction, a low-density core with high-density glass-cloth faces, offers the possibility of utilizing the high compressive strengths and compensating for the greater deflections inherent with the lower modulus of glass cloth. The Materiel Command glass cloth-balsa sandwich BT-15 fuselage deflections were considerably less under equivalent loading than those of the standard aluminum and wooden semi-monocoque fuselages, due to the buckling of such sections. Other advantages have been discussed previously.

### New combination suggested

The properties of uni-directional glass cloth in the direction of the fibers are approximately double those of cross-laminated glass cloth. Utilization of this high strength and rigidity for members such as spar caps or stringers, where multi-directional properties are not essential, will result in increased strength and reduced deflections in structural components. This consideration at once suggests a combination of uni-directional stiffening elements with multi-directional skin. Such a design is under consideration by the Materiel Command at the present time.

12—The sandwich fuselage made of glass-cloth laminate showed no signs of buckling at 180 percent of design load. 13—As can be seen, in the test the metal fuselage buckled severely at 100 percent of design load



# Forms, properties and handling of glass reinforcements\*

The Research Laboratories of Owens-Corning Fiberglas Corp. located at Newark, Ohio, are under the supervision of Games Slayter, vice-president in charge of research. Activities are organized in ten major divisions under the general supervision of Dr. A. W. Davison, scientific director; H. W. Collins, assistant director of research; and Dale Kleist, engineering director. Four of the major divisions are concerned with pure research in glass, chemistry, chemical engineering, physics and metallurgy. Activities of the other 6 divisions are devoted to the application of research to processes and products.

Research aimed at developing techniques for the fabrication of glass-reinforced, low-pressure plastics suitable for the construction of structural aircraft parts was directed by a committee headed by H. W. Collins, assistant director of research. Other members of the committee were: Charles Jones, chairman; Robert B. Taylor and Harold Loudin, physics laboratory; Clayton Smucker, Erven White, Dr. Robert Steinman and Dr. L. P. Biefeld, chemistry laboratory; Ray B. Cropps and Milton Gallagher, testing laboratory.

**M**ANY of the standard forms of fibrous glass appear to be suitable for use as reinforcement for low-pressure plastics, but to date the forms chiefly employed by fabricators or in experimental work are continuous filament, all-glass cloths and warps; uni-directional cloths, i.e., cloths with a glass warp and cotton fill; and glass fiber flock of extremely fine fibers having lengths measurable in millimeters. All-glass cloths, uni-directional cloths and flock were used in preparing laminated test samples under the Air-Forces-sponsored research program.

All-glass cloths woven of continuous filament fiber yarns, uni-directional cloths and glass warps provide a high concentration of the fibers, and are usually used as reinforcing material when high strength is desired. Strength of the laminate can be varied by using a cloth with a tight or open weave, by varying the number of plies of cloth for a given thickness or by dispersing flock in the resin to serve as lateral reinforcement. These variables make it possible to cover a wide range of strengths.

## Fiber properties studied

Since the properties of a multiple fiber material such as glass cloth are largely dependent upon the properties of the individual fibers, exhaustive studies of the fibers have been conducted to determine their properties. Special

apparatus has been designed and built for this particular purpose.

Modulus of elasticity and tensile strength are of primary importance. The modulus of elasticity holds fairly constant at 8,000,000 to 9,000,000 p.s.i. for glass fibers between 0.00070 and 0.00020 in. in diameter—a range which includes the standard textile fibers. An upward trend is shown for fibers of smaller diameter. The tensile strength of the standard textile fibers is in the order of 300,000 p.s.i., but the tensile strength increases as the diameter of the fibers decreases. Experimental fibers have been produced with a tensile strength exceeding 2,000,000 p.s.i.

The fibers will melt, but they will not burn. Because they are solid glass rods with no cellular interstructure, they will not absorb moisture. They will not rot or mildew. They are the result of oxidation and, unlike metallic and organic fibers, can exist indefinitely in an atmosphere of oxygen.

## High dimensional stability

An unusual feature of the fibers is that they have tensile strengths in excess of those of the high-strength metals, and yet they have many times the elongation of these metals before the elastic limit is reached. As a matter of fact, the elongation of a glass fiber at break is about the same as that of a cotton fiber. This accounts for the extremely high impact resistance of glass-reinforced plastics. The alloying and heat treating of metals is largely aimed at raising the elastic limit closer to the ultimate strength. In glass fibers they are one and the same.

Because the fibers do not swell under the influence of moisture and elongate only under great tension, they possess high dimensional stability. This dimensional stability is imparted to the plastics in which the glass fibers are used for reinforcement. The lower limit of the plastic flow of glass textile fibers is at about 200° C. The thermal coefficient of linear expansion is  $49 \times 10^{-7}$  per °C. for temperatures up to 300°. An actual increase in the tensile strength of glass cloth is obtained by subjecting it to temperatures as high as 200° C. The cloth can be subjected to higher temperatures for short periods without serious loss of strength.

Practically no shrinkage of the cloth occurs at temperatures below 100° C. At 400° C., shrinkage is only 0.30 to 0.35 percent. Between 375 and 425° C., the rate of shrinkage increases sharply and continues at a higher rate, although still showing a shrinkage of only 0.90 percent at 600° C. These temperatures, however, are in excess of curing temperatures, so the factor of shrinkage may be disregarded in the preparation of glass-reinforced plastics.

## Heat treatment of cloths

The effect of heat upon glass cloth is of particular interest since heat treating of glass cloth to be used as plastic reinforcement is one of the most important of the techniques developed by the Fiberglas laboratories. This treatment is required in order to obtain maximum adhesion of the resin to the glass.

\* This article was prepared by members of the staff of the Research Laboratories, Owens-Corning Fiberglas Corp.

All fibers that are to be formed into yarns or fabrics must have a lubricant to prevent them from abrading one another. In the case of animal and vegetable fibers such as wool and cotton, this lubricant is present in the fiber. In the case of glass fibers, the lubricant must be added to permit the forming and fabrication of the textiles. The ingredients of the glass lubricant are dextrinized starch, oil, gelatin, neutral emulsifier, complex amine salt and polyvinyl alcohol.

To obtain adhesion between the resin and the glass fibers, certain of these ingredients must be volatilized; others must undergo a change and remain on the fibers if the textiles are to retain properties they must possess to serve as plastics reinforcement. Exhaustive tests have demonstrated that the required adhesion values and maintenance of the necessary textile properties can best be provided by heat treating the textiles. The same tests have shown that increase in adhesion caused by the heat treat-



GAMES SLAYTER

ment is a principal factor contributing to the high strengths obtained with glass-reinforced laminates. Caramelization of the starch in the lubricant is an easily perceptible effect of the heat treatment.

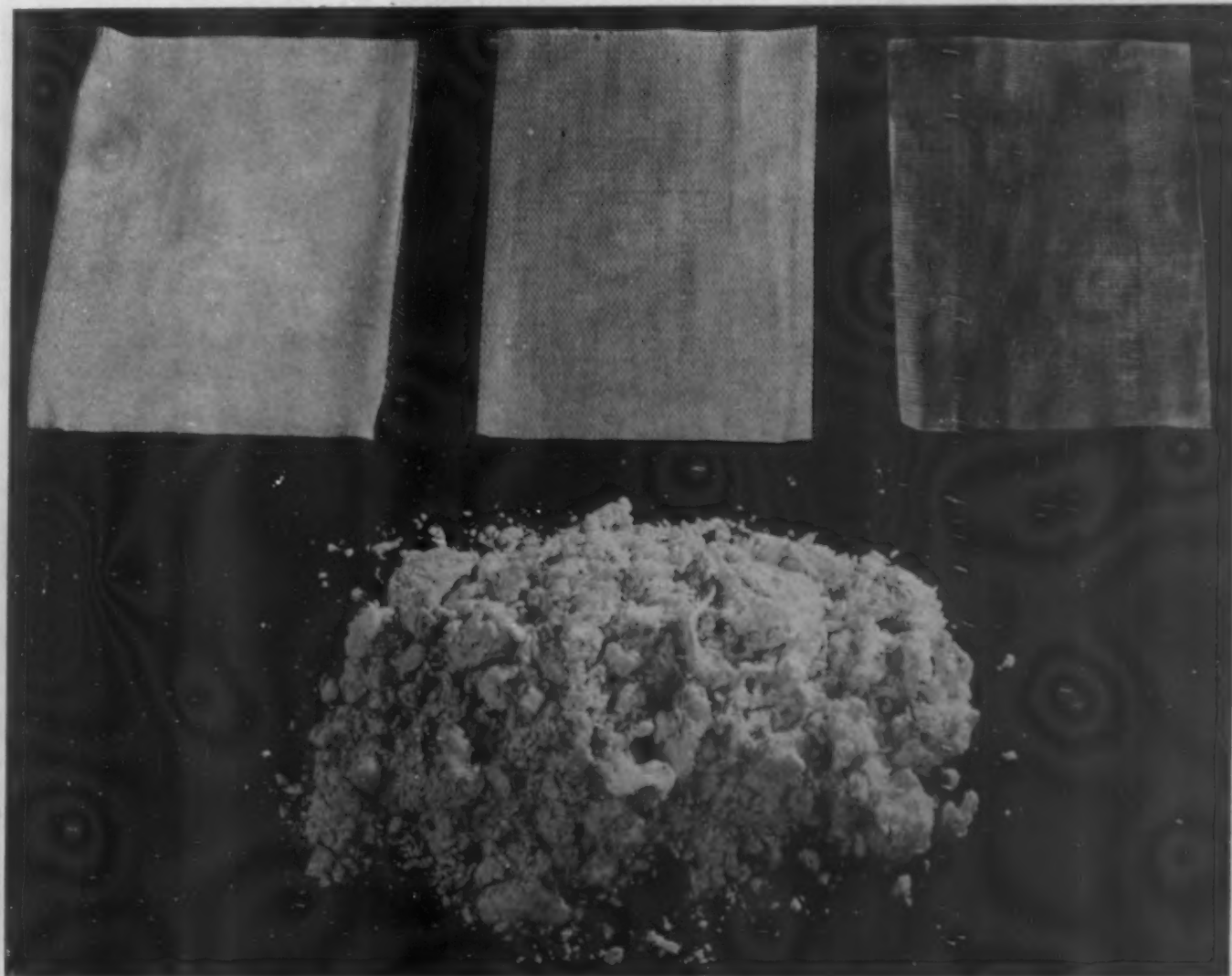
A uniform brown appearance of the textile, caused by caramelization of the starch, is visual indication of satisfactory treatment. Other effects are removal of the oils and practically all of the moisture, and fixation of a starch-gelatin film on the fiber. This film affords a firmly anchored base for adhesion with the resin.

#### Meticulous procedure required

To achieve the best results in the fabrication of glass-reinforced plastics, the procedure employed must be meticulous. In the preparation of the plastics the major effort must be directed toward getting the glass fibers to work as small columns in compression. To accomplish this the fibers must be supported

1—The square of OC-64 glass cloth at the left has not yet been subjected to heat treatment or impregnation. At this stage the cloth is pure white. In the middle is a piece of this same cloth which has been heat treated but not as yet impregnated with resin. The brownish sample at the right has been heat treated and impregnated with a resin which previously was mixed with a percentage of flock fiber. This flock is shown in the foreground

ALL PHOTOS IN THIS ARTICLE, COURTESY OWENS-CORNING FIBERGLAS CORP.





2—One method of heat treating glass cloth makes use of revolving heated rolls

at exceedingly small intervals, necessitating the exclusion of fine dust and bubbles or other contamination that would interfere with such support.

As an indication of how important this is, the critical compression loads which can be developed in small diameter columns should be considered. To achieve a composite compressive strength of 75,000 p.s.i., using 50 percent glass fibers by volume, all parallel to the direction of load, the glass must take a compressive stress of 140,000 p.s.i., assuming that the resin is working at a compressive stress of 20,000 p.s.i. With this value for the critical stress that must be developed in the fiber, and a fiber diameter of 20 one-hundred-thousandths of an inch, the fiber must be supported along its entire length at distances not exceeding 100 one-hundred-thousandths of an inch.

Several methods for heat treating the textiles have been devised by these laboratories. A satisfactory method consists in festooning the cloth in an oven. Since the hot air can circulate freely through the draped material, the hot gaseous products of the treatment are not concentrated in spots. The treatment should be at about 200° C. for 2 hours. The temperature of the interior of the oven must be uniform, and the air must be circulated. The glass textiles can also be satisfactorily heat treated by passing them through a hot-air zone, using higher temperatures and subjecting the materials to these temperatures for a shorter time. Good results have been obtained by passing a medium-weight cloth at a rate of 2½ ft. per min. through a tower having a hot-air zone 10 ft. long and heated to about 340° C. Cloths of different weights require different speeds. Another continuous heat-treating method utilizes heated revolving rolls. Because the cloth is in contact with the rolls, higher temperatures and speeds can be employed.

#### Assembly of fibers

Before undertaking to reinforce a plastic with glass fibers, it is necessary to determine whether the material is to carry

tensile forces only, as in a tie-rod; or whether it is to encounter both tensile and compressive forces, as in a beam; or whether it will carry compressive forces only as in a strut.

If tensile loads alone must be taken into consideration, all fibers should run in one direction, parallel to the tensile stress. A warp made of parallel strands of fibers can be used. An alternative is to use a uni-directional cloth, laminating it so that the glass yarns are parallel.

If concerned with compressive loads only, the reinforcement can be introduced in the same manner as for tensile loads but with the fibers placed at right angles to the compressive stress. This can be done by using layers of all-glass cloth or by cross-laminating uni-directional fabrics or warps. This manner of reinforcing satisfies the condition known as "flat-wise" compression. Compressive strengths are obtained exceeding those secured by other methods of fiber-resin assembly.

The Poisson's ratio of glass is about 0.25, while most resins have a Poisson's ratio in the neighborhood of 0.45 to 0.50. This indicates that most resins will act in a manner similar to that of hydraulic fluids. In any mechanical assembly of the two materials, this probable hydraulic action of the resin should be kept in mind.

The reason the above method of obtaining high compressive strength is so effective is that the hydraulic action of the resin, due to its high Poisson's ratio, gives comparatively high sidewise deformation under compressive loading, and works the fibers in tension. Compressive strengths can be obtained closely approaching the best tensile strengths obtainable when high tensile strength is the objective, but the tensile strength of this particular material is low, since it has only the tensile strength of the resin in the direction of the major stress.

When approximately equal tensile and compressive strengths are sought, it is necessary to use a laminated structure similar to that employed for compressive loads only, and at the same time provide for considerable lateral reinforcement between the various plies to prevent delamination



3

in compression. Firm adhesion is essential to develop strong interfaces between the resins and the fibers in order to ensure high compressive stresses in the individual fibers.

The necessary lateral reinforcement can be obtained by dispersing flock in the resin. There is a possibility that a method may be devised for applying the flock to the other fibers electrostatically, so that each strand of these other fibers would look like a furry caterpillar. Pure resin could then be applied in the normal manner.

#### Modulus of elasticity controllable

The modulus of elasticity of glass-reinforced plastics is affected by condition of cure of the resin, fiber diameter, close-



4

ness of weave and direction of fibers, and by the glass-to-resin ratio.

Woven all-glass fabrics, or cross-laminated, uni-directional fabrics, give values of the modulus on the order of 2 to 2½ million p.s.i. If the reinforcing fibers are predominantly in the same direction, as in parallel-laminated, uni-directional cloths, it is possible to increase the Young's modulus to 4½ million p.s.i.

These values are based on the premise that optimum curing of the resins has occurred. By under-curing the resins, reducing the glass-resin ratio and using loose, square-woven cloths, it is possible to obtain Young's moduli very closely approaching that of the pure resin.

5



3—In a second simple method of heat treating glass cloth, an oven is used. 4—A high-production method for heat treating the cloth makes use of a hot-air tower and mechanical rolling and conveying equipment. The material is pure white as it enters the hot-air tower (lower right). As it emerges from the tower (upper center) it is light tan in color. 5—In measuring tensile strength and modulus of elasticity of a single fiber, the test load is gradually increased by changing catenary of the chain shown at upper right

# Fabrication of experimental low-pressure laminates\*

**T**HE techniques employed by the Fiberglas laboratories in preparing glass-reinforced, low-pressure laminates are not suggested as suitable for large-scale production. They are purely laboratory techniques, practical for the production of small experimental quantities. They are reported here as a matter of record to show the methods used in achieving the data submitted under the research which was sponsored by the Army Air Forces.

All laminates prepared by the laboratories were cured between  $\frac{1}{4}$  in. thick tempered glass plates so that smooth surfaces could be obtained. To prevent the glass plates from adhering to the laminates, the contact surfaces of the plates were separated from the glass-reinforced laminates by means of sheets of cellophane cut to size.

## Cloth impregnation

One method used in working with the low-viscosity resins was to combine the resin with the glass-cloth reinforcement by brush impregnation. Each cloth was impregnated as the laminate was built up on a glass plate covered with cellophane. The cloths were brushed carefully toward the edges to remove entrapped air bubbles and were rolled down with a metal roller to assure intimate contact and exclude air. When all the plies were in place, a second sheet of cellophane and a second plate of glass were placed on the laminate. Care was taken to avoid the inclusion of air.

Because this method of impregnation might result in the inclusion of air bubbles despite all precautions, an alternative method was developed. The desired number of plies of dry cloth were assembled on a cellophane-covered glass plate, and a pool of resin was poured in the center. Additional resin was slowly added, so that it soaked down through the plies and out to the edges. A sheet of cellophane was placed on the top ply, the excess resin was wiped from the center outward with a spatula and a second glass plate was added.

When fine glass-fiber flock was dispersed in the resin to obtain increased inter-laminar strength, this pouring technique could not be employed. The individual plies were brushed in place with resin, and then rolled down. Addition of the flock, however, produced a semi-gel stage which helped hold the plies of cloth in place during lamination.

## Handling viscous resins

The more viscous resins were applied in a thin layer to a piece of sheet metal and strips of the glass cloth were laid on the metal sheet. Additional resin was then put on the cloth



H. W. COLLINS

and spread with a squeegee over the entire surface until the cloth was completely impregnated. The excess resin was wiped off and the impregnated cloth cut to size. Each ply was rolled down as the laminate was built up.

Condensing resins were applied to the cloth by the use of a dip pan. The cloth was dipped by pulling under a roll-rod below the surface of the resin solution, the speed of dipping being regulated to ensure thorough wetting. The squeeze rods were set to remove excess resin and to provide an even distribution on the cloth.

The impregnated cloth was treated to advance the resin to the intermediate stage by drying and aging, either in an oven or over a longer

period of time at room conditions. The cloth was then cut to size and laminated.

## Curing oven and press

All laminates were cured under pressure in an electrically heated oven. A small fan provided internal air circulation necessary to maintain uniform temperatures throughout the entire oven enclosure. Checks of temperature variations from top to bottom of the oven showed variations of only  $3^{\circ}\text{C}$ . in the laminates.

A press was installed inside the oven to transmit pressures to the laminates. This press consisted of a framework on the bottom of which was a round steel plate resting on a diaphragm, and laminates to be cured were blocked between the plate and the top framework. Angle irons, laid on edge parallel to the direction of air flow, were placed between the laminates to permit an even distribution of heat.

An air line which was connected under the diaphragm gave accurate and easily controlled pressure regulation for from 1 to 6 laminates cured simultaneously. The pressure was uniform throughout the entire cure cycle, regardless of shrinkage in the laminates, because the diaphragm expanded as the shrinkage occurred. Temperature readings were taken with a thermometer extending into the oven through the center of one of the sides.

Such of these general procedures as were applicable were applied in preparing the test laminates under the Air-Forces-sponsored research program.

## Curing schedules

In preparing laminates with Laminac P-4122, 0.5 percent Alperox C was used as a catalyst. This was stirred into the resin at room temperature with an electric agitator. Three percent, by weight, of flock fibers was then dispersed in the resin, using a heavy-duty mixer with a gyratory paddle.

\* This article was prepared by members of the staff of the Research Laboratories, Owens-Corning Fiberglas Corp.

A tempered-glass plate was laid on the work bench, covered with a sheet of cellophane, and the first ply of glass cloth was laid down. Resin was brushed into the cloth, and the cloth was rolled with a metal roller. This procedure was repeated for each ply. When the laminate had been built up to the required thickness, another sheet of cellophane and another glass plate were laid on.

The  $\frac{1}{4}$ -in.-thick laminates were cured in the oven under 15 p.s.i. pressure for 2 hr. at 70° C., and for 5 hr. at 110° C. They were then removed from between the glass plates and cured an additional 4 hr. at 110° C. The  $\frac{1}{2}$ -in. laminates were cured for 3 hr. at 60° C., 3 hr. at 80° and 6 hr. at 110°.

Five percent Lucidol was used as a catalyst in preparing laminates with C-39 resin. Flock fibers were mixed in a portion of the resin to obtain a thick putty which was then mixed with additional resin to obtain a final fiber concentration of 3 percent by weight. Prior to lamination, the cloth was treated with a 0.5 percent solution of wetting agent<sup>1</sup> G-30. The laminates were built up in the same manner as the Laminac laminates.

The  $\frac{1}{4}$ -in. CR-39 laminates were cured under 15 p.s.i. pressure for 12 hr. at 74 to 115° C., and for 3 hr. at 115°. The  $\frac{1}{2}$ -in. laminates were cured for 6 hr. at 60° C., 3 hr. at 70°, 12 hr. at 70 to 115° and 3 hr. at 115°.

Laminates with MR-1A were formed in the same way, except that there was no treatment of the cloth with the wetting agent. Laminates with CR-39Bd were built up in the same way as the MR-1A laminates but with 3 percent Lucidol as the catalyst. Curing pressures for MR-1A and CR-39Bd laminates were 15 p.s.i. Curing schedules were: MR-1A,  $\frac{1}{4}$ -in. laminates—9 hr. at 74 to 115° C., 3 hr. at 115° C.;  $\frac{1}{2}$ -in. laminates—3 hr. at 60° C., 3 hr. at 70°

12 hr. at 70 to 115°, 3 hr. at 115°. CR-39Bd,  $\frac{1}{4}$ -in. laminates—12 hr. at 60° C., 9 hr. at 74 to 115°, 3 hr. at 115°;  $\frac{1}{2}$ -in. laminates—72 hr. at 60° C., 3 hr. at 115°.

In preparing laminates with CR-149, 5 percent Lucidol was used as a catalyst. The laminates were formed in the same manner as those using CR-39 except that no flock fiber and no wetting agent were used. Curing was done between tempered glass plates at 15 p.s.i. for 12 hr. at 70° C., 2 hr. at 80° and 2 hr. at 115°.

Plaskon 900 is supplied in two parts. One hundred parts of A were mixed with 17 $\frac{1}{2}$  parts of B, and 2 percent Lucidol was added as a catalyst. Three percent of flock fibers by weight was dispersed in the resin. Because Plaskon 900 is too viscous for brush impregnation, the method described for the handling of viscous resin was applied to the preparation of the laminates. These were cured in the oven in the same manner and under the same pressure as the other laminates.

The curing cycle for the  $\frac{1}{4}$ -in. laminates was 2 hr. at 60° C., 2 hr. at 80°, 2 hr. at 110°. The glass plates were then removed and the laminates were cured an additional 4 hr. at 110°. The  $\frac{1}{2}$ -in. laminates were cured for 3 hr. at 50° C., 3 hr. at 80°, 3 hr. at 110°. After removal of the glass plates they were cured another 4 hr. at 110°.

Monsanto 38691 is also supplied in two parts. One hundred parts of A were mixed with 30 parts of B. One-half part Lucidol was used as a catalyst. The laminates were prepared in the same way as the Plaskon 900 laminates. Both the  $\frac{1}{4}$ -in. and  $\frac{1}{2}$ -in. laminates were cured under 15 p.s.i. pressure for 10 hr. at 70° C., and for 15 hr. at 110°.

To permit uniform cooling on the surfaces and to prevent warping, all laminates were set on edge to cool after completion of the cure.

(Please turn to next page)

<sup>1</sup> Supplied by Dow-Corning Corp.

1—A resin of a very heavy molasses type being spread on the glass-cloth by means of a squeegee.  
2—A dipping method is employed to impregnate the glass-cloth with a condensing-type resin

ALL PHOTOS IN THIS ARTICLE, COURTESY OWENS-CORNING FIBERGLAS CORP.





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### Time of cure reducible

The cure schedules described were based upon previous cure studies and are applicable only to these particular curing procedures. Because of differences in rate of heat transfer, it is not correct to assume that the same results would be obtained if similar laminates were cured for the same time and at the same temperatures in a platen press by the bag molding process, or with the use of plates of steel.

It is probable that the time of the cure can be materially reduced by designing curing equipment for the specific job and by using materials which will permit more rapid application of heat and better dissipation of the internal heat during the exothermic stages of the reaction.

Test specimens were cut from the cured laminates with a band saw, using a metal cutting blade with 10 to 12 teeth per



4

inch. Speeds were somewhat in excess of metal cutting practice, being 2500 f.p.m. A sanding disk and sanding belt were used to machine the specimens to exact size.

Before testing, all specimens were conditioned for at least 96 hr. at 25° C., and 50 percent relative humidity. The conditioning cabinet was controlled to  $\pm 0.5^\circ$  C. by means of circulating air maintained at the desired temperature. The specified 50 percent relative humidity was obtained with a saturated solution of calcium nitrate.

All specimens were tested on standard test devices and by standard test procedures, in accordance with Federal Specification L-P-406. Test procedures were inspected by representatives of the Engineering Division of the Materiel Command. Test results were verified by the Materiel Command, Wright Field.

3—Impregnated glass-cloth being built up to form a laminate. 4—Laminates are placed between tempered glass plates before insertion in laboratory press. Angle irons allow free circulation of heated air between laminates. 5—Laminates and press in curing oven. 6—Sanding tensile test specimen to exact shape and size

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# Machining glass-reinforced low-pressure laminates

by FRANK E. ALLEN\*

**M**ACHINABILITY is an important property of glass-reinforced, low-pressure laminates. Standard tools will perform satisfactorily and, in general, procedures are the same as those employed in machining the metals.

Removal of chips and dust by suction is recommended. Compressed air is the best coolant while water is as good as any liquid. A coolant that contains an oil or fatty base or a solvent may do permanent damage by softening or penetrating the plastic. All liquid coolants have the disadvantage of combining with fine dust and setting into a hard cake that interferes with the machining operations.

## Drilling

In drilling parallel to the laminations, care must be taken to prevent splitting. The material should be clamped in a vise or between plates. After the hole has been started in its proper location, a bottom drill with a slow feed should be used.

When drilling perpendicular to the lamination this precaution is not necessary, but the material should be backed with a tightly clamped support of wood or metal until the drill has passed completely through the piece. This prevents breaking out and gives a clean, sharp hole.

Satisfactory results may be obtained in drilling holes up to  $\frac{3}{16}$  in. in diameter by using regular high-speed steel drills such as are employed in drilling steel, with a slightly negative rake ground on the cutting lip that is dubbed off as in drilling brass. It is advisable to back out the drill frequently to avoid burning. A cutting speed of 80 ft. per min. with a feed ratio of 0.002 to 0.004 per revolution has been found to meet usual conditions. A thin jet of compressed air directed as near the hole as possible and directly on the tool helps materially to keep the drill cool.

Specially designed, carboloy-tipped drills for plastics are available and should always be used in drilling holes larger than  $\frac{3}{16}$  in. in diameter. These drills have highly polished flutes, maximum chip clearance, slow helix for blind holes with a  $55^\circ$  point for thin sections and a  $90^\circ$  point for thick sections. Most drilled holes will be found to be 0.001 to 0.003 in. undersize. However, if the drill cuts oversize, this condition may be overcome by grinding a slight radius at the end of the lip.

Other types of drills which may be used if the holes are over  $\frac{3}{16}$  and under  $1\frac{1}{2}$  in. are the masonry type and the gun drill. Both should be carboloy-tipped. In thin laminates, large holes can be cut with a gasket cutter, or may be sawed with a circular saw-tooth cutter such as is used to cut holes in



FRANK E. ALLEN

sheet metal. Large holes can be cut in thicker laminates by the abrasive-type drills used to take sample cones from concrete roadways, walls and foundations. Portable machines of this kind can be obtained which will drill holes from  $\frac{1}{2}$  to 8 in. in diameter and up to 27 in. in depth. Drills used in the machines can be adapted for use in standard drill presses.

Still another way of cutting large holes is in a lathe, boring mill or milling machine. A starting hole is drilled and bored to size in the same manner as in ordinary metal-machining operations. The boring tool should be ground with a minimum of clearance and no back slope. A side slope of  $13^\circ$  has been found satisfactory. The cutting angle should be  $55$  to  $60^\circ$ . The tool should be set so that the heel of the cutting angle cuts in advance of the point, in order

that a clean cutting edge free from fins may be maintained.

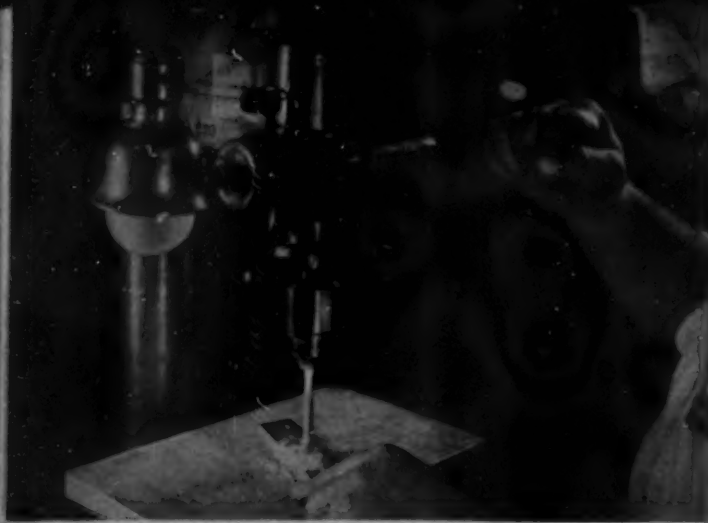
If duplicate drilling is desired, drill jigs should be designed with slip bushings. After the work is spotted, the bushings can be removed. This will reduce the friction on the drill and avoid high bushing replacement caused by the abrasive action of the chips between the bushing and the drill. If a limited amount of duplicate work is all that is required, a layout templet can be used to locate the holes. When starting, if the drill runs to one side it can be brought back into proper location by drawing over, by chipping or by filing a groove on the side from which it has moved away. This must be done before the drill point has completely entered the material.

## Punching

Sheet laminates may be punched for both holes and blanks. The recommended minimum distance between the holes and the edge of the sheet is 3 times the thickness of the sheet. Punched holes should not be smaller in diameter than the thickness of the sheet. A very close fit approaching a sliding fit, is required between punch and die. A close fit is also necessary for the pressure stripper to produce clean-edged holes and prevent the punch from pulling up the edge of the hole as it is pulled from the material. Laminated materials yield somewhat when punched, and as a result the hole which is produced is slightly smaller than the punch. In punching as well as in blanking, allowance of about 3 percent of the thickness punched must be made for this yield.

Shear helps somewhat in the power required and in some instances makes a cleaner edge blank, but is not recommended for holes, as one side of the punch, stripping first, will raise the edge of the material. In blanking, shear should be applied to the punch only. In punching holes no back clear-

\* Research Laboratories, Owens-Corning Fiberglas Corp.



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ance should be given the punch, as this would leave too much clearance between punch and stripper and pull up the edge of the hole on its back stroke. In blanking, the edges may be somewhat torn or rough between surfaces. This may be remedied by punching a larger blank and then passing it through a shaving die—i.e., a hollow or ring die with a 45° cutting edge. Number 6 Stellite applied by oxyacetylene welding is recommended for the cutting edge. This should be put on a soft steel die body.

The punch should be soft brass, slightly concave on the face, and should be a sheared fit. When the punch becomes worn it should be peened oversize and again sheared in so that it will fit the die as closely as possible.

The stroke of the press should be adjusted so that the punch clears the blank out of the die at each stroke. If the blanks are allowed to build up in the die, shavings may drop in between blanks, causing them to cock and tear up the edges as they are forced out. Die design in general is the same as for metal, and standard punch-press equipment is used.

### Sawing

Laminates can be sawed with all types of hand metal-cutting saws. A set one-half the thickness of the blade on each side and 10 to 12 t.p.i. is recommended. Circular saws used to cut holes in sheet metal can be used in a drill press. Speed should not exceed 2000 ft. per minute. Abrasive saws are satisfactory for cutting out blocks. The type of machine used for cutting refractory blocks works very well on rough work, with a Clipper C-R-3-14-6 wheel.

In using an abrasive saw, it is better to pass the saw back and forth across the work, taking several cuts, instead of taking a full depth cut at one time. This prevents heating, and the life of the saw is much longer. For general purposes, a band saw is the best. This can be the standard metal-cutting band saw, or the conventional wood-band saw with a metal table. Metal-cutting saws should have the teeth set to clear one-half of the thickness of the blade each side, 8 to 10 t.p.i., 20 to 23 gage, with width of the blade governed by the radius to be cut.

### Grinding

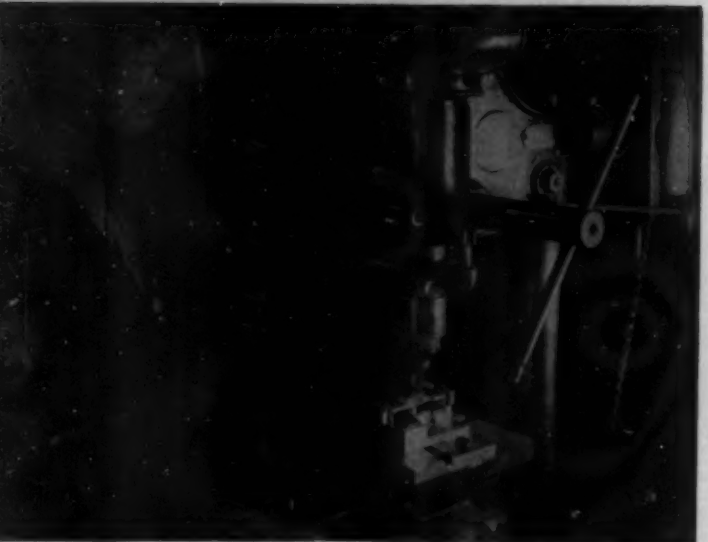
With the proper wheel, grinding can be done with light cuts and feed, but it has a tendency to heat up the fibers. Sanding works very well both for stock removal and finishing. The endless-belt type of sander is recommended, although a disk cylinder or drum sander can be used. Numbers 50 to 80 grit, with a surface speed of 2700 to 3000 ft. per min., work well.

It is better to use dry sanding, with suction to remove the dust, than a liquid coolant for the same reason that a liquid coolant is not recommended for other machining operations—the dust combines with the coolant to form a stiff paste which adheres to the machine and interferes with its operation.

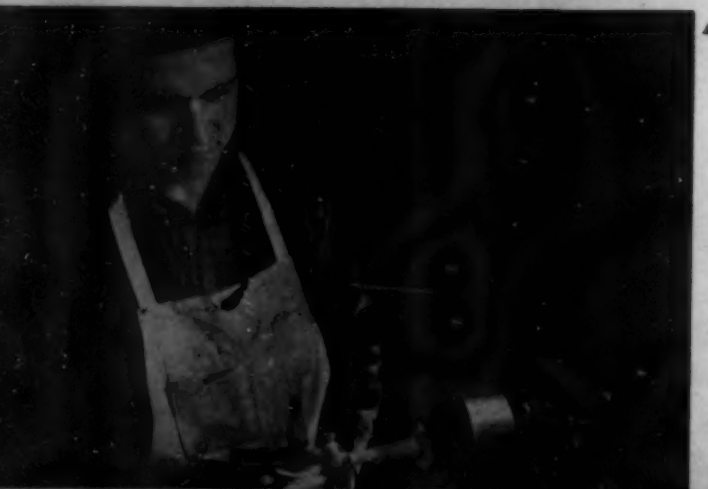
1—For holes up to 3/16 in. in diameter, satisfactory results may be obtained through the use of regular high-speed steel drills. In this illustration a carbide masonry drill is being used to drill a 3/8-in. hole in the laminate. 2—Band saws similar to the one used in sawing this laminate have proved most satisfactory for general purposes. 3—A test specimen being ground to size and shape. 4—When turning laminates such as this shear test specimen, metal cutting lathes are used



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ALL PHOTOS IN THIS ARTICLE, COURTESY OWENS-CORNING FIBERGLAS CORP.



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5—The flat surface of a laminate is here being shaped or planed. The cutting tool used for this work should be tungsten-carbide tipped. 6—A spiral 4-fluted end mill is being used on this tool to mill the recess in this glass-reinforced laminate

## Turning

For turning, metal cutting lathes are used with speeds of 150 to 200 surface ft. per min. and a feed of 0.010 in. per revolution. Tungsten-carbide-tipped tools, ground with a 33° clearance angle, no back slope or lip, and with a side slope of 13°, have been found satisfactory. Female centers are much better than male centers in turning laminated stock due to the male center's tendency to wedge apart the laminations. When facing or counter-boring, the cut should be toward the center.

In both facing and turning, the tool should be set so that the heel of the cutting edge cuts in advance of the point in order to shear in the direction of the stock being removed. If the point is set in advance of the heel of the cutting edge, it will tend to peel off the stock and throw up a fin or burr.

## Tapping and threading

For tapping and threading, high-speed nitrated and chromium-plated taps are best. Ground taps are desirable. Three-fluted or two-fluted spiral gun taps are recommended. A negative rake of 5° on the front face of the land will help avoid binding and stripping of the thread when the tap is backed out. Taps should be 0.002 to 0.008 in. oversize since there is a tendency for the material to close up when the tap is removed. To prevent splitting, laminates must be clamped when tapping parallel with the lamination. The edges of the holes should be chamfered and supported so that they will not be raised up by the tap.

Holes to be tapped should be larger than is customary for metal in order to leave only about 75 percent of a full thread. This will prevent the top of the thread from breaking or peeling off, and give a cleaner job. If tapping is done in a machine, a speed of 40 to 50 ft. per min. is satisfactory. Water is a good tapping medium and dries off quickly. Threads can be chased in a lathe on solid stock but have a tendency to break or peel off in laminated material.

When chasing V threads, the lathe compound should be thrown around to 30°, and the tool ground to cut one side only. This will help overcome this difficulty.

## Milling

Tungsten-carbide-tipped cutters should be used for milling, and the cutting angle should be ground with a slight rake. Best results are obtained at high machining speeds, 400 to 800 ft. per minute. Indications are that at high cutting speeds the reinforced plastic ruptures ahead of the tool edge, which thus assumes a wedge function. The edge of the tool does not come in contact with the glass and is thus protected, the wear coming just back of the cutting edge. At lower speeds the plastic is pushed up to the very edge of the cutter, which has to cut the glass by impact. This wears the cutter edge and generates excessive heat. The danger of lifting the lamination at the edge of the cut will be reduced if the set-up is made so that the mill cuts down on the material.

## Planing or shaping

In planing or shaping, the cutting speeds can be from 50 to 80 surface ft. per min., with a feed from 0.010 to 0.015 in. per stroke. The cutting tool should be tungsten-carbide-tipped and should have a cutting angle of 36°, a clearance angle of 30° and a shearing angle of 45°. The tool must be set so that the cut is shearing action from the surface of the work backward and down. This method will give clean cuts and a smooth finish.

## Shearing

Thin sheet laminates can be cut by hand with sheet-metal shears, or they can be cut with foot-power square shears such as are used for thin sheet metal. Sheets 1/8 to 3/8 in. in thickness can be cut on power shears used for steel plate. The cutting edges of the shears will give greater production between grinds and longer blade life if the tool is faced with Number 6 Stellite.



# Desirable handling properties of low-pressure resins

by J. D. LINCOLN\*

**R**ECENT developments in the laminating of glass fibers have directed attention toward the resins which are being used in these operations. The purpose of this article is to discuss the desirable handling properties of resins, with special reference to those resins which are used in the low-pressure and no-pressure field. In this discussion, the major points in question are: 1) the molding conditions necessary to form the fabrics with resins, and 2) the viscosity and other handling characteristics from the point of view of "easy lay-up" and temporary storage between the time of impregnation and actual use.

Since our company first began its experimental work in low-pressure laminating, many types of resins have been submitted for tests and used in production. While all of these resins were classed as no-pressure resins, they had one great drawback which did more to hold up the successful development of this new industry than any other factor: the viscosity of these resins was very low and, consequently, no great weight of resin could be picked up and held by whatever fabric was being coated. This condition was partially the fault of the resin manufacturers' instructions as to the method of coating wherein the "brush-on" method of applying the resin to the fabric was advocated. As a matter of fact, many forms were laid up before any resin was applied at all, and then a regular housepainting job was done on the outside of the form. As a result, a great amount of material was wasted and irretrievably lost. This process was indeed slow so far as actual production was concerned, and the quality of the completed article was very poor. There was no such thing as uniformity from piece to piece and molding temperatures and cycles could not be standardized.

The reason for this condition was quite simple. A resin that is liquid enough to brush on will run, and the low section

or sections—including any pockets—will take the run-off from the higher portions of the form. This results in "fat spots" which are those portions of the form which have accumulated the excess quantity of resin. Fat spots result in soggy, undercured sections and, as a matter of fact, are cause for complete rejection of the part. This run-off also results in "starved" spots which are just the reverse of the fat spots. These starved sections, instead of having the required weight of resin, have lost practically all their coating. This behavior results in weak sections in the parts being molded and sometimes causes blisters.

Since this inauspicious beginning, several companies have developed a resin whose heavy viscosity has eliminated many major difficulties. This resin, which becomes liquid in a temperature range of 125-150° F., may be metered on the cloth by means of a doctor knife or through the use of rolls. In its liquid condition, the resin entirely saturates and coats any substance which is passed through it. However, upon a return to room temperature, the resin assumes the viscosity of a heavy grease. No drying is necessary. Because the material remains in a sticky or tacky condition, fabrics can be "laid up" with great ease. No tacking either with metal staples or soldering irons is required, since the material actually clings to the form not only at certain points but over its entire area. The impregnated fabrics instead of being stiff and harsh as they are when the resin is partially polymerized, are soft and pliable. This property permits them to be stretched and formed so that they will accurately fit compound curvatures and sharp bends and angles. Careful consideration indicates that it would be physically impossible to mass-produce complicated forms and shapes of the new super-strength glass-laminated material without using this type of grease-like resin.

The first block of this resin-laminate material which was

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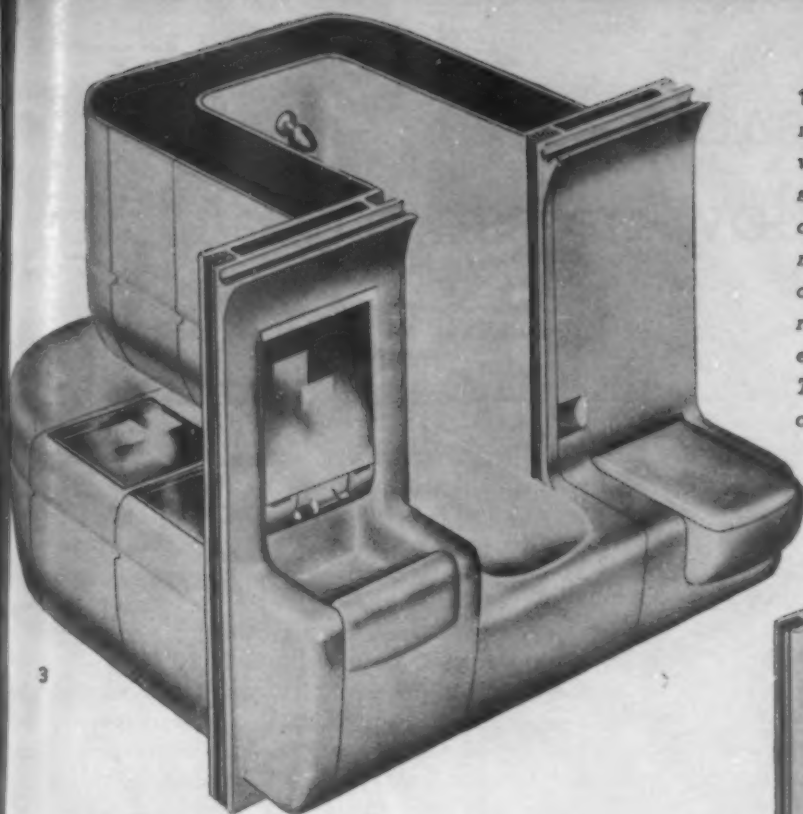


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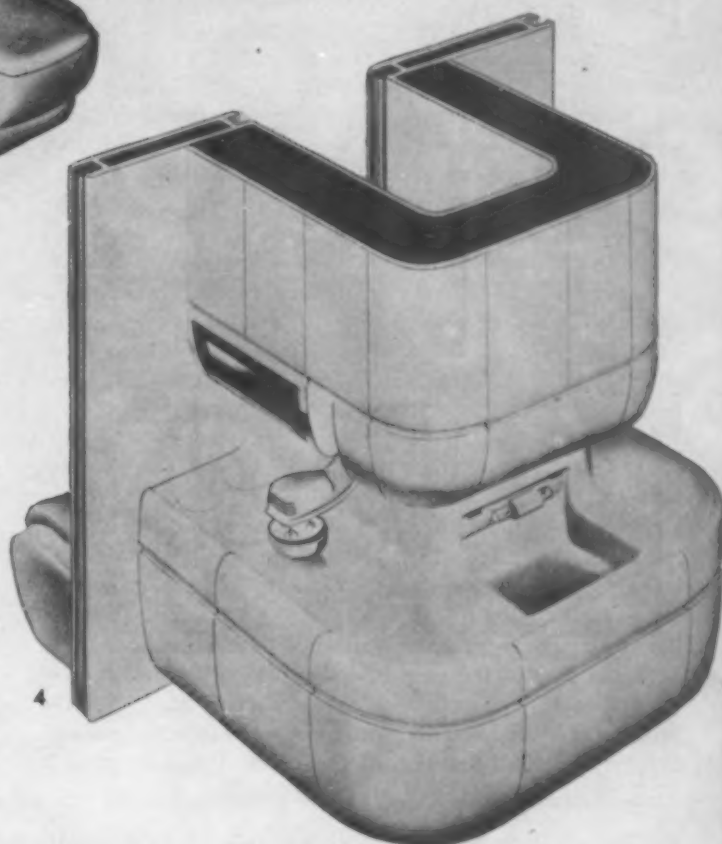


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produced at our company might have been described as a multitude of straight-line fibers. These fibers—carried along separated from one another by means of a comb or other similar device—were dipped in the warm liquid resin, grease-like at room temperature. It was at this point that the development by Owens-Corning Fiberglas Corp. produced such astounding results. Chopped, finely divided glass-fiber flock with a fiber diameter approximately one-sixth that of the main fibers was mixed in the liquid resin. The straight-line fibers in passing through the resin picked up a coating composed of resin and short lengths of chopped glass fiber. These tiny filaments interspersed among the straight-line strands served as reinforcement. The method might better be described by saying that the straight-line strands resemble the warp of the laminate and the chopped fibers resemble the fill, the resin holding all components in position. If the resin did not assume a grease-like consistency at room temperature, there would be nothing to hold the fibers together after their removal from the resin bath. Consequently, it would be impossible to lay up forms, and the uniform admixture of resin, fibers and strands would be destroyed.

In our opinion it is important to find resins that will polymerize at temperatures below 250° F., because temperatures of that degree or greater will shorten the life of the rubber bag used in molding the parts. Temperatures on the order of 200–220° F. would increase the life of these bags at least 10 times. Great savings would result from the continuation of this same line of reasoning into the high-pressure laminating field. It is true that the actual pressure required for laminating is not very expensive to maintain. However, the development of the heat needed to polymerize the center sections of thick laminates is very expensive. Even though the temperature of the steam platens transmits the heat to the outer glue lines almost instantly, it sometimes takes hours to raise the temperature of the center sections of the glue lines to a degree which will completely cure the part. While it is true that high-frequency heat is very fast and will raise the

1—Traveling bags in the era following the war may be similar to the cases shown in this sketch which are light in weight and highly scuff and scratch resistant. 2—This streamlined chair design lends itself admirably to low-pressure molding. 3 and 4—A feature of these architects' designs is the grouping of kitchen and bath-room units in a small space. As can be seen, each assembly is divided into small sections. This construction makes possible a wide variety of arrangements to fit homes both old and new



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temperature of glue lines very rapidly, this equipment is still not widely available and is rather expensive. Therefore, reduction of the temperature necessary to cure laminating resins would appreciably reduce the operating costs both in high-pressure and low-pressure laminating.

Future study by resin manufacturers should point the way to resins which will cure with no pressure and no heat. These resins would be known as unstable resins and their curing would be brought about by the addition of a catalyst rather than by the addition of any heat or pressure. They could be made stable for a matter of minutes or probably an hour. Such resins which are in the laboratory stage at the moment could probably be very quickly made available to the laminators. It is true that certain types of intricate forms wherein the forming requires a great deal of time would not be adaptable to the use of such fast resins. However, there are many uses to which this type of material could be put, and it is strongly recommended that development work be brought to a conclusion as soon as possible.

Thanks are extended to all suppliers for the whole-hearted cooperation the company has received over the past few years. Only through this cooperation have we been able to reach our present development.



# The versatility of low-pressure molding

by DAVID SWEDLOW\*

**P**RESENT a sample of one of the new contact or low-pressure resins with a high-strength filler such as glass fibers to a design engineer. Mention various properties of this material, such as high tensile strength in the range of aluminum alloy, good resistance to solvents and stability at extreme temperatures. Explain the simplicity of the tools and the ease with which this plastic can be fabricated. Immediately the designer has dreamed up a complete body or fuselage to be made in one piece simply by wrapping the glass fabric around a simple wood or plaster form, saturating the material with a proper resin and then placing the assembly in an oven. Presto! You have your complete fuselage.

But in the apparent simplicity of this process lie many of the pitfalls and dangers in the proper development of this new and intensely interesting field of low-pressure plastics. While contemplation of the unlimited possibilities of this new development certainly fires the imagination, fabricators who have tackled the problem have learned to "make haste slowly." A review of some of the problems and of the progress made in taking the low-pressure plastics from the laboratory stage through research and development and, in some cases, into production will perhaps be the best means of illustrating the significance of this new development.

In the case of the contact resins, which use pressures of from 0 to 10 p.s.i., the molder is not confronted with the problem of forcing volatile matter out of the resin by pressure. Pressure is not a function of the cure. Polymerization is

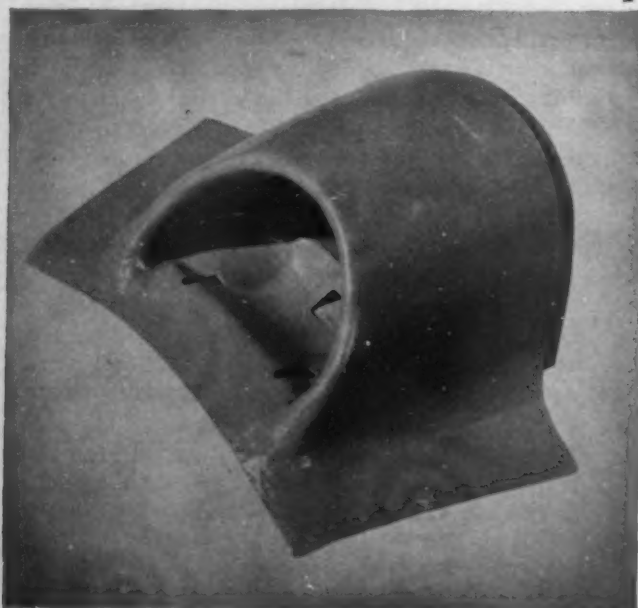
\* President and general manager, Swedlow Aeroplastics Corp.

1—This airplane fuel tank is an example of the application of low-pressure resin with high-strength filler such as glass fibers to the molding of shaped parts. 2—Low-pressure laminates when used for such parts as this air scoop can definitely show man-hour and price savings

ALL PHOTOS, COURTESY SWEDLOW AEROPLASTICS CORP.



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brought about by the addition of a catalytic agent which induces oxidation at elevated temperatures, and the resin changes from the liquid to the solid state. The manufacture of these low-pressure laminates falls into two general types—the production of flat sheet and fabrication of shaped parts.

Considerable progress has been made during the past year on methods for producing flat sheet. The early processes were cumbersome and impractical, involving the following operations: 1) submerging the filler material in a vacuum tank containing the resin, 2) placing the impregnated material between two pieces of glass while still submerged, 3) rolling out the trapped air, 4) wiping off the plates, 5) curing in an oven for 8 hr., and 6) in many cases breaking the tempered glass to remove the cured laminate.

In the present method of automatically producing flat sheet, the equipment 1) properly dries the filler, 2) automatically impregnates the filler with a proper resin content, and 3) cures the laminate in a tunnel oven in a cycle of from 30 min. to 2 hr., depending upon the type of laminate. This is indeed a step forward. Two very significant developments in flat sheet are the production of a thermosetting sheet which can be readily post-formed, and the manufacture of a semi-cured sheet which is very flexible and can be held in place on a simple wood form and flash-cured in a matter of 10 to 15 minutes.

A description of the progress made in the development of shaped parts is more involved because each shape presents a different problem. To achieve (Please turn to page 184)

# MARKING METHACRYLATE

**T**RANSSPARENT wall plaques etched with the intricate design of the cactus. Graceful fanlights traced with a stylized pattern of spring flowers. While these samples are representative of the beauty that can be achieved through the engraving of methacrylate sheet, there are many other acrylic pieces which, while requiring less imagination and skill in their marking, yet must be stamped permanently with numbers, initials, trademarks or dial calibrations.

Although in many cases numbers and letters can be molded in, this practice may increase the cost of the mold to a point where it is more economical to mark the piece after it has been removed from the press. Furthermore, this type of marking lacks adaptability and is impractical when, for example, successive serial numbers are to be stamped on each piece. Of the other available methods of marking, each offers certain advantages in speed, economy, accuracy or permanency.

## Engraving

When a relatively small quantity of parts is involved, individual pieces of methacrylate can be hand engraved by almost any jeweler. This plastic is of about the same order of hardness and has working qualities quite similar to those of copper. Consequently, essentially the same tools and techniques may be used for methacrylate as are employed in copper or silver engraving.

Alternately, there are several types of engraving machines which depend for their cutting action on a rotating tool.

Material for this article was supplied by Rohm & Haas Co.

These tools, which may be similar to a dentist's burr or a small grinding wheel, are driven by a motor incorporated in the machine itself or transmitting its power through a flexible shaft. In most cases the latter type of drive is preferable for detail work since it permits closer control of the cutting action. Because of the transparency of the material, a 3-dimensional effect may be obtained by cutting designs on the back of the sheet to different depths. It is also possible to obtain different surface effects varying from a smooth frosting to a white grain by a judicious choice of cutting tool or stone. The decorative plaques shown on this page are excellent examples of the artistic handling of engraving tools.

A modification of this equipment is a machine similar to those used for engraving copper plates for intaglio printing. In this process the operator moves a stylus through a master die of the desired marking which is usually several times larger than the size required on the finished part. This movement is transmitted and reduced by a pantograph device to the rotating cutting tool which reproduces the design on the methacrylate surface. To give greater visibility to any engraved marking, an oil or japan pigment obtainable at art supply and paint stores may be wiped into the cutting.

## Sandblasting

The sandblasting of various designs on this plastic is particularly suitable when large areas are involved. Although the resiliency of the material makes it difficult to sandblast methacrylate to any great depth, it is possible to obtain attractive over-all frosting after (Please turn to page 188)



THESE CONCEALED RINGS OR FLUSH DRAWER pulls are typical examples of the great thoroughness with which the Navy forestalls every conceivable possibility of accident aboard ship. When mortised into the face of the drawer, these pulls obviate the use of protruding knobs which might prove dangerous in close, shifting quarters.

All the parts for this single pull are molded in a 24-sec. cycle from medium-hard cellulose acetate butyrate. Since a comparatively small number of parts were required, it would have proved impossible to justify or amortize the cost of a multi-cavity mold with movable pins. The molder relied for initial production on what is virtually a sample cavity incorporated in a standard mold blank. Thus he was able to produce economically on a scale in which plastics ordinarily could scarcely compete if the usual fairly expensive and complicated injection mold had been built in anticipation of an expected volume which might not materialize. If the order should be increased, it is merely necessary to buy a larger stock mold blank and have a second or third cavity made.

To eliminate the drilling of the hinge pin hole through the long hinge portion of the pull ring and to avoid the use of moving mold parts, a pin is inserted in the die and molded into the ring. After molding the temporary pin is pushed out, and the ring retainer plate itself drilled to receive the hinge pin which is pressed firmly into place after the ring is set for assembly.

*Credits—Material: Tenite II. Molded by Tri-State Plastic Molding Co. for the U. S. Navy*

VACUUM BOTTLES LIKE THESE ENJOYED increased popularity at the outbreak of hostilities when a large part of the adult world not enlisted in the country's Armed Services turned to the production of implements of war. Since working hours are long and lunch periods necessarily brief, more people than ever came to rely on these heat-retaining flasks for essential liquid nourishment.

## PRODUCT

However, the metal of which the outer barrels of many of these vacuums were constructed had also gone to war, and manufacturers were faced with the need for a non-priority material with properties similar to those of metal. Turning to plastics, one vacuum bottle manufacturer found that fiber board impregnated with water-resistant synthetic resins equalled and even surpassed the metal in rigidity, heat resistance and appearance. In fact, this material has definite advantages over metal in corrosion resistance and is lighter in weight.

In the method finally chosen for the production of these vacuum bottle barrels, the specially selected board is pre-impregnated with the thermosetting resin. This stock is partially cured and then wound convolutely in several plies on a mandrel. The laminating agent is another and completely different thermosetting resin emulsion. The composite of alternate laminations of pre-impregnated fiber and adhesive resins gives the barrel its primary form. The barrel is then air-dried for a predetermined period of time, subjected to carefully controlled heat for slightly shorter intervals, and again dried. The vacuum bottle barrels are then ready for a wrinkle finish. As a final step they are baked at temperatures in excess of 270° F. The completed product, a composite of fibers and resins, has proved highly satisfactory, the consumers' only complaint being that they cannot get enough.

*Credits—Material: paper board, Robt. Gair Co., Inc., and International Paper Co. Impregnated with synthetic resins supplied by American Cyanamid Co. and Carbide and Carbon Chemicals Corp. Plastic-fiber barrels manufactured by Cambridge Paper Box Co., Inc., for American Thermos Bottle Co.*



## DEVELOPMENT

THIS COMPTORPLUG, WHICH IS MADE UP OF AN amplifier and an expansion plug locking together, provides a highly accurate comparator gage for use where identical holes are to be produced in quantity. The amplifier is designed to accommodate all of the various sizes of plugs which are employed to measure to fractional ten-thousandths the diameter of any part of a hole.

The original aluminum amplifier castings required approximately 67 expensive machine operations. However, when a medium-impact, cotton-flock filled, phenolic molding compound was adopted, molders were able to reduce these operations to 12 simple steps and to provide a permanent, attractive finish. Reduction of the operating time to slightly less than a minute for molding and to 4 min. for the curing cycles, makes possible the production of 1000 units per week. In addition, the weight of the plastic housing is one-half that of the aluminum casting and the cost is about one-third.

A slight redesign of the pieces which comprise the amplifier was found to be necessary to adapt the instrument to plastic molding. A semi-automatic, compression-type mold was built, incorporating 2 cavities of almost equal size and shape—one for the case and the other for the cover. An added rib around the outside periphery minimized the joint when the cover and base were assembled. Eight metal inserts are used in the base. Four are needed to accommodate the clamping screws in the cover assembly, while the other 4 inserts support mounting screws which are necessary in over-all assembly operations. The dial bezel contains 3 inserts for mounting on the dial plate, and a knurled design is molded around



the bezel periphery to simplify adjustment. The dial plates are molded with 3 counter-sunk holes which correspond to assembly holes in the front of the body. The plastic design also incorporates the customer's monogram and a stippled area for styling and streamlining.

*Credits—Material: Textolite. Molded by Plastics Division, General Electric Co., for Comptor Co.*

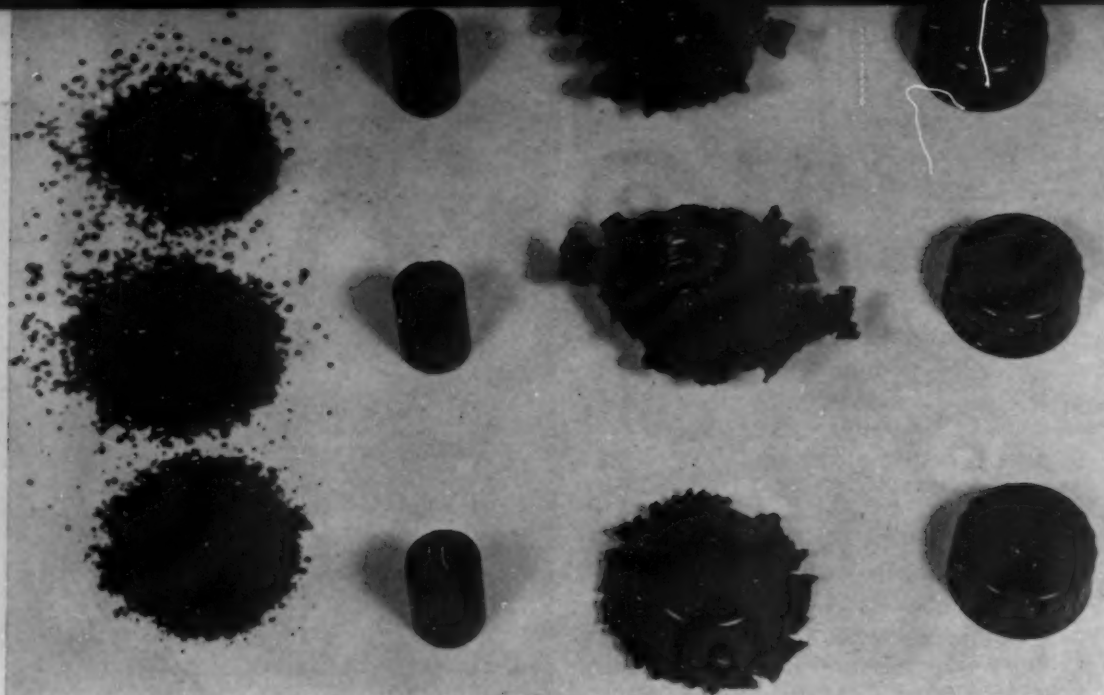


OFFICE CHAIRS OF THE FUTURE WILL BE LIGHTER in weight than the standard models now in use, and streamlined to suit the most up-to-the-minute office interior if present activities of plastic researchers are a true indication of future production in furniture manufacture. Model chairs which are sturdy, yet slender and graceful, with backs molded of a sisal reinforced phenolic resin are already being shown. They have a distinctive natural texture and combine rigidity and elasticity in high resistance to strain.

These new chairs consist of four pieces—a seat back unit, two leg units and one cross member. The parts are quickly assembled by the use of only 5 screws. A structure of this size would be difficult if not impossible to mold by conventional methods of high-pressure molding. That is why a process of fluid pressure molding is utilized in its manufacture. This type of molding permits the chair to be reinforced at strain points with reinforcing members bonded directly to the chair structure itself. The seat back unit is molded of a sisal reinforced phenolic resin adapted to low-pressure molding, and the leg units are of plastic-bonded birch veneer. Unlike metal, the chair is warm to the touch, and emerges from the mold completely finished except for trimming.

The materials of which the chair is composed are too critical to permit its production in any sizable quantity at this time. However, its appearance opens up an entirely new vista of promising postwar applications of plastics.

*Credits—Material: back, Co-Ro-Lite; plywood legs, Amberlite resin. Designed and molded by Vidal Research Corp.*



## New urea formula for stripping

by W. H. MacHALE\*

**T**HE word "stripping" needs little explanation to members of the molding industry, but for those less familiar with the vernacular of the trade, we shall attempt a definition. A stripping molding compound is one which, after molding, retains for a limited period of time sufficient elasticity to permit its ejection over substantial undercuts. A case in point is the ejection of threaded bottle caps from threaded force plugs without the necessity of an unscrewing operation.

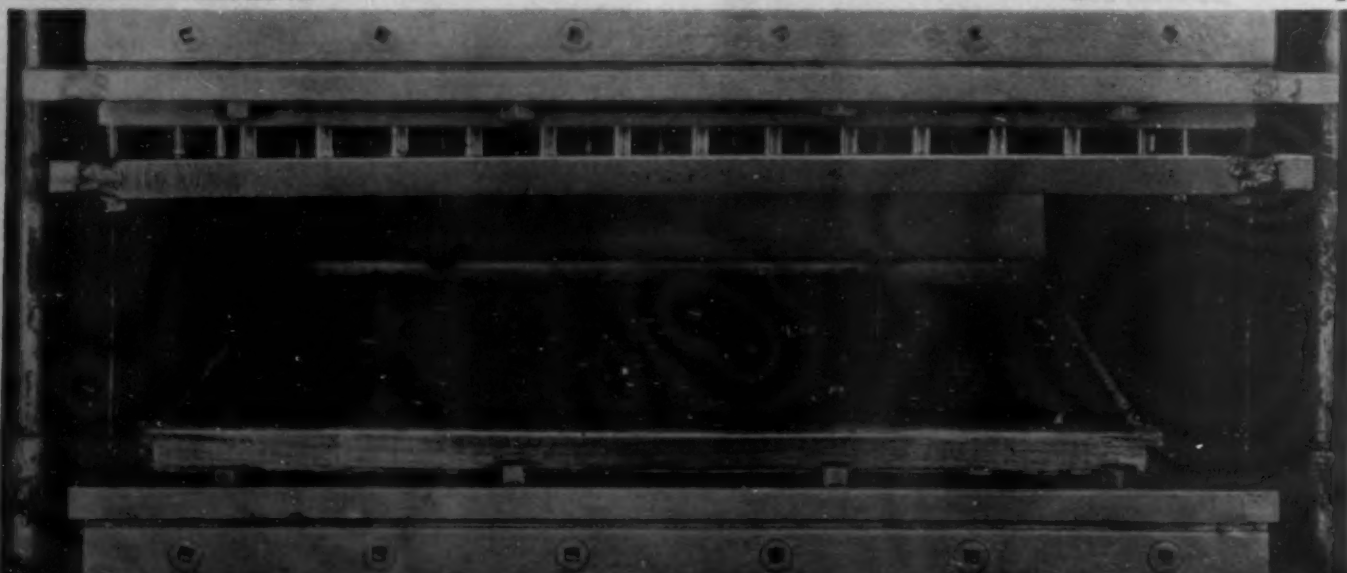
Until the outbreak of the war practically all thermosetting stripping materials were phenolic. Prior to that date, some work had been done by urea suppliers to meet the demand for colored materials from molders equipped with a stripping setup. Although this early work contributed to eventual

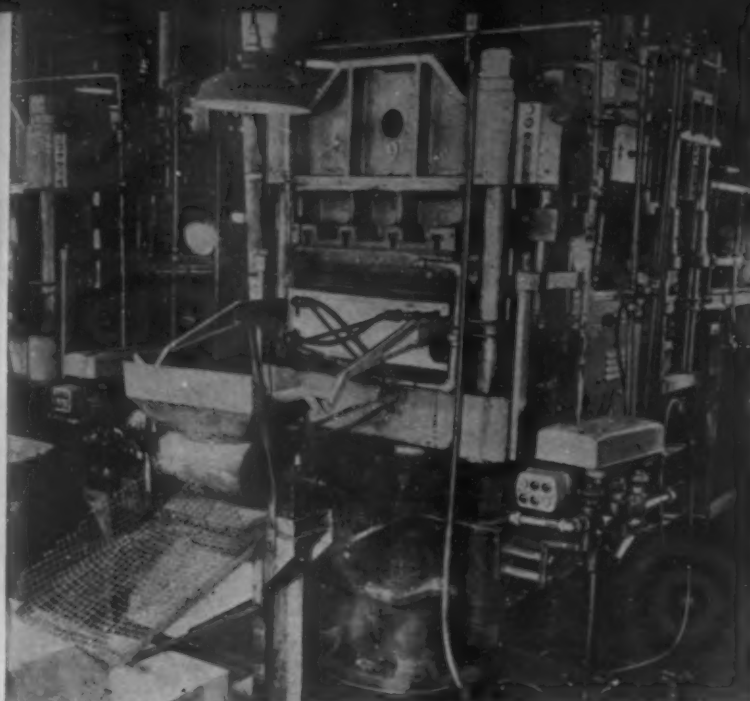
success, it was not until 1942—just about the time a serious shortage of phenolics occurred—that a successful stripping urea material was produced which met the performance record of its predecessors, the phenolics.

Development work on this new compound was largely confined to molding conditions existent at the Boonton Molding Co. and in the Anchor Hocking Glass Corp. plant. In discussing the success of this material, George Scribner, president of Boonton Molding Co., stated that while his plant had for years made a fairly complete line of phenolic caps—ranging from 8 mm. to 100 mm.—one problem was the lack of urea colors in the phenolic material. When efforts were made by the company to fill orders for caps in pastel colors using urea compounds, it found that rejects for cracks ran to at least

1—In the molding of caps from stripping urea-formaldehyde molding compounds, the plastic (left) is compressed into pills (left center). After preformed caps with flash adhering to their edges (right center) are tumble finished, they are ready for shipment (right). 2—Stripped from the force plugs, the caps drop into an unloading tray

PHOTOS, COURTESY ANCHOR HOCKING GLASS CORP.





3 PHOTO, COURTESY BOONTON MOLDING CO.



4

3—In this automatic closure molding machine the material is picked up as it comes from a barrel (right background) and preformed. After being loaded on a loading fixture, the preforms are dropped into the cavities and molded. Stripped from the threaded force plugs, the molded caps are delivered to the automatic tumbling barrel which takes off the flash. The finished caps are then shunted into the shipping cartons. 4—A close-up of the press and tumbling barrel. A load of caps has just been cleaned of flash and transferred to a shipping box

20 percent. Such was the situation when the outbreak of war cut off phenolic for liquor closures—the company's principal market for caps. According to Mr. Scribner, the Sayre automatic molding machine used in the plant held the cost of molding caps to such a low figure that the company could have continued producing the caps at a profit even with 20 percent rejects. Such a rejection percentage, however, is far from being good for the general morale of the shop.

Mr. Scribner stated that today, as a result of the timely development of this stripping urea compound, his company can out-produce phenolic with urea. The complete molding cycle at this plant is 45 sec. to make 96 pieces of the 28 mm. caps or 60 pieces of the 38 mm. On this basis 18 sec. are allowed for open time and 27 sec. for each preform and preheat at 260° F. and mold at 320° F. These two latter periods are identical because they are simultaneous and in series. According to Mr. Scribner, the only difficulty that has arisen in the switch-over from phenolic to urea material rests on the fact that a bit more pressure is needed. He emphasized that while the company can compensate on phenolic by raising the temperature, it cannot do this on the urea.

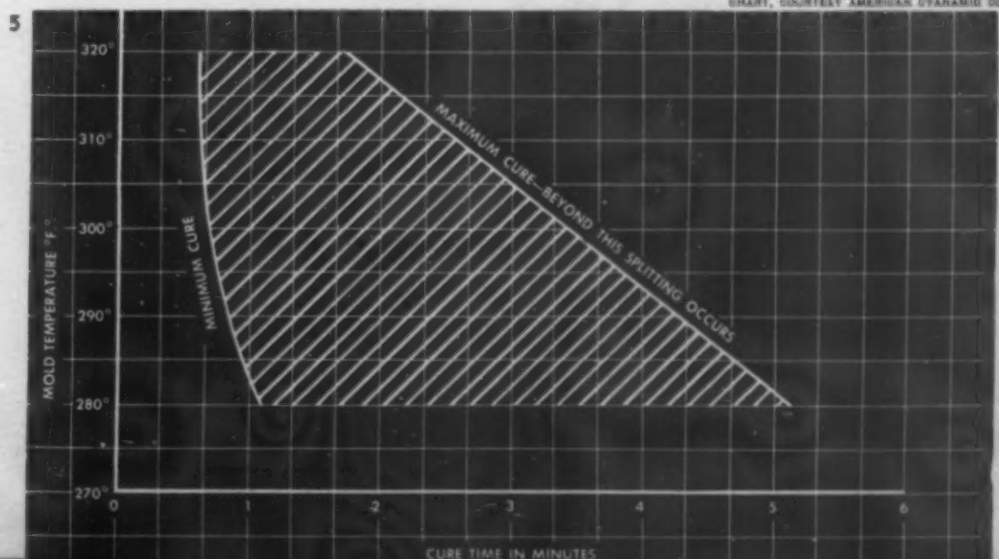
At first the plant experienced some trouble on tumbling urea because the flash was tougher. However, this condition was corrected by an adjustment of the tumbling mechanism. Mr. Scribner stated that cap rejects are about 2 percent overall—very few from cracks. Thus far the company has only operated on brown. The standard material, costing 27½ cents, has been used at the plant in preference to the newer material which has less resin content and sells for 22 cents.

#### Properties of urea stripping materials

Stripping urea meets the following five requirements for a closure material:

1. Extra flexibility for easy stripping—flexural strength 13 percent higher than regular urea-formaldehyde materials.
2. Fast cure for high-production rates.
3. Improved torque strength—from 25 to 90 percent stronger than regular urea-formaldehyde compounds, depending on the test methods used.
4. Low shrinkage—on the low side of regular urea-formaldehyde materials.
5. Good moldability and (Please turn to page 192)

5—This graph indicates the stripping ranges at various temperatures. The point of maximum cure beyond which splitting occurs is indicated on the drawing



# PLASTICS IN REVIEW

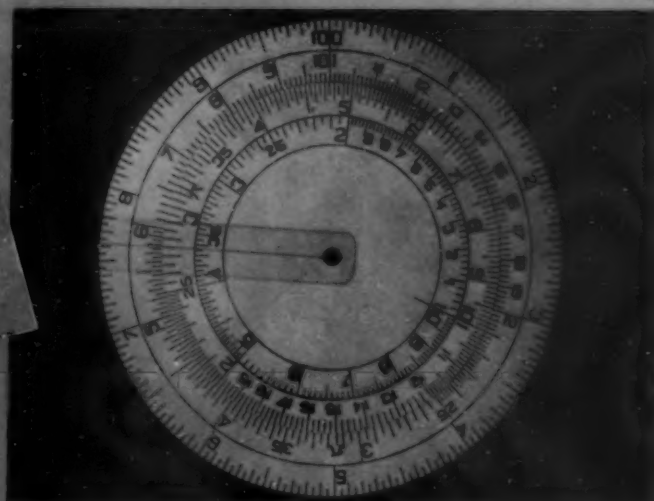
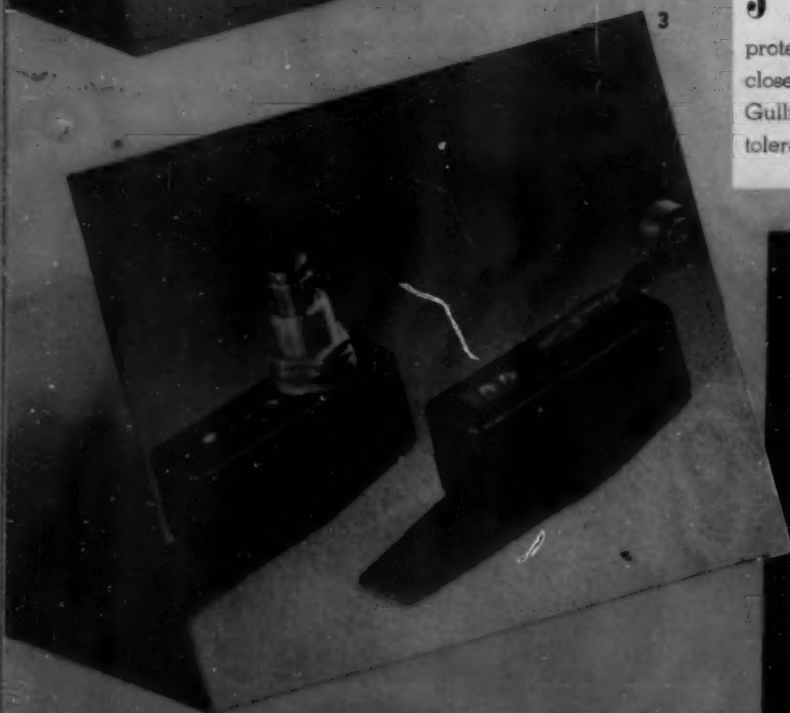


**1** Fluorescent light sources are effectively shielded by a polystyrene lighting tray, injection molded in one piece for the Miller Co. by General Electric Co., Plastics Divisions. The tray is approximately 12 in. square, with a shot through the center which is later machined



**2** The Navy is providing enlisted personnel with a whistle made of Tenite II. Cellulose acetate butyrate was selected for this application because of its low water-absorption and ability to retain dimensions under varying climatic conditions. The whistle is injection molded by T. F. Butterfield, Inc., in 2 pieces which are glued together after molding

**3** These precision snap-action electric switches ensure quick and efficient control of various parts of an airplane. As a protection against corrosion and fracture, the switches are enclosed in a Bakelite housing, compression molded by the Wm. M. Gulliksen Mfg. Co. for the Mu-Switch Corp. to exactly specific tolerances





5



6



7

**4** A welcome addition to a busy estimator's equipment is a circular slide rule which can fit in a pocket or brief case, yet is so accurate as to allow calculations within  $1/4$  of one percent. The Monitor rule is fabricated of white Vinylite by Sillcocks-Miller Co. for Tavella Sales Co.

**5** These plastic badges are being distributed by the Navy Department to civilian employees in recognition of outstanding service to the Navy. Each of the 3 plies of acid-resistant Duroplastic, the acetate sheet from which the pins are fabricated by Whitehead and Hoag Co., is 0.020 in. thick. Printing is done on the center opaque ply which is then laminated to the 2 outer transparent sheets

**6** To minimize the hazards of a traffic policeman's duties, this powerful flashlight molded of Lumarith X is equipped with a solid Lucite extension rod, tinted red on the outside except at the end. These Traf-O-Lites, produced by Gits Molding Corp., are also invaluable to guards and firemen

**7** These ink distributing rollers for offset presses and duplicators, fabricated of Lucite by the Lumerol Co., are being used with remarkable success in Government printing agencies and commercial firms. The use of transparent methyl methacrylate reduces the danger of ink remaining unnoticed on the rollers and hardening

**8** To brighten the drudgery of dishwashing, plastic sink strainers designed to blend with prevailing color schemes have appeared on the consumer markets. These strainers are injection molded of Tenite or Tenite II in one-cavity dies, by the Plastic Die and Tool Corp.

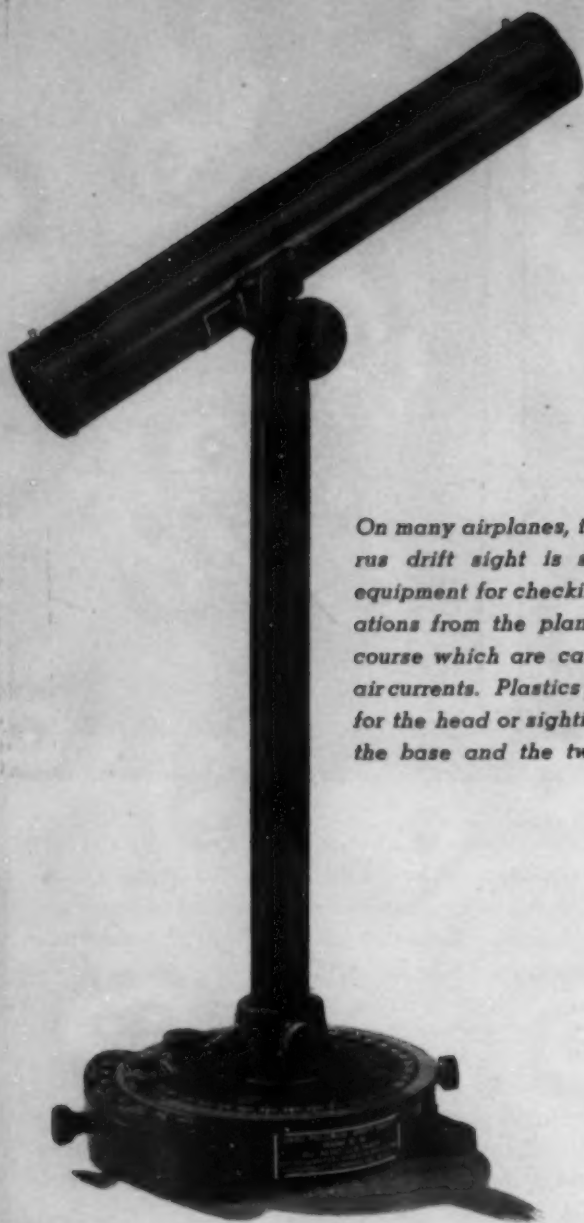
**9** Ammunition components for holding charges in all sizes of projectiles are being made of Celluloid in increasing quantities. The transparency of these cellulose nitrate parts has reduced the number of duds because empty containers are immediately apparent. In addition, explosion hazards are reduced since the smooth edges of the components do not cause sparks



8



9



*On many airplanes, the pelorus drift sight is standard equipment for checking deviations from the plane's true course which are caused by air currents. Plastics are used for the head or sighting tube, the base and the two dials*

## Pelorus drift sight

by NED G. LEVIEN\*

**T**HE vital role of navigational instruments in the far-flung operations of our airborne troops is increasingly recognized. A basic item of such equipment is the pelorus drift sight which makes it possible to maintain a constant check on deviations from the plane's true course which arise from air currents. A plastic replacement for the original all-metal assembly is one of the most recent additions to the list of navigational aids produced from synthetic materials.

Known as the Mark II-B non-recording pelorus drift sight, this instrument is designed to function either as a pelorus for taking bearings on objects or as a means for measuring the angle between heading and actual track of a plane. Its plastic components consist of the head, which includes a sighting tube attached by a metal yoke to a vertical cylinder, the base, and two dials (Fig. 1). One of these dials, known as the pelorus ring or azimuth scale, is graduated through 360° of the arc and enables the navigator to take true or relative bearings for the purpose of fixing his position. The plastic drift scale which is graduated from -40 to +40° indicates the direction and amount of drift as related to the navigational problem.

The remaining metal parts of the instrument include a central insert for the housing of the upright cylinder, a revolving

indicator arm, reinforcing inserts in the feet and various screws and controlling knobs.

In selecting the materials for this application, strength, durability and weathering resistance were among the chief requisites. In view of the fact that the sight must be used over water in a variety of climatic conditions, the last of these qualifications was especially important.

An impact-resistant phenolic material was selected for the compression molded base. When the question of the dials was considered, XX laminated sheet was chosen because it could be machined to close tolerances and easily marked by hot branding. The possibility of dimensional changes in these parts due to weathering and the consequent danger of binding presented a serious problem. To meet the necessary specifications, each experimental assembly was required to function freely after subjection to the most extreme temperature and moisture conditions ever encountered in use. With the aid of skilful machining, dials were finally produced which successfully passed all the tests, an accuracy of 1/4 of 1° being maintained for a 4-in. dial showing the full 360°.

Even greater difficulties were confronted in planning the head of the instrument. Among these was the extremely careful milling involved in producing the 10-in. lateral groove in the vertical cylinder. This channel acts as a key way for the knob in the indicator arm, making it possible to lower or raise the sight tube. The knob also serves to hold the tube at any desired elevation. Every effort was therefore made to ensure an exact fit between key way and key, a feat which was finally accomplished by maintaining a tolerance of  $\pm 0.0005$  for the groove. To guard against buckling, which would result in binding the key, the machined cylinder was passed through the same weathering tests as those used for the plastic dials. Experiments showed that the original tolerance of  $\pm 0.001$  specified for the 3/4-in. diameter cylinder must be slightly broadened to offset the contraction and expansion resulting from temperature changes.

The sight tube, also formed from laminated paper-base tubing, was Cyclewelded to a supporting metal yoke attached to the vertical cylinder. The sight itself, a slot parallel with the axis of the tubing, was achieved only by virtue of the most painstaking milling. It was also necessary that this tube be adjusted to move with pinpoint precision since the plane of the arc described by its upward and downward movement must be exactly aligned with the plane of the base. To facilitate night observations, a narrow lateral groove, marked in white, was also machined along the top of the tube.

The indicator arm is a complicated mechanism which was constructed to very close tolerances and finished in accordance with the standards set for precision instruments. Great care should be taken to locate the sight in a position which is accessible with a maximum field to the rear and downward.

*Credits—Material: base, Bakelite. Molded by Accurate Molding Corp.; dials and paper-base laminates, Formica, Synthane. Formed by Rogan Bros.; pelorus drift sight manufactured by Ivorycraft Co., Inc.*

\* Ivorycraft Co., Inc.

# PLASTICS\*

Engineering Section

F. B. STANLEY, Editor



## THREE NEWCOMERS

**W**HEN a merchant ship is struck by a torpedo or heavy caliber shell, the resultant explosion or fire is likely to jam doors and bulkheads, thereby blocking the escape of seamen caught below deck. This danger is recognized in the new mandatory marine regulations which state, in part, that "doors should not be considered satisfactory means of escape unless provision is made against their jamming or unless an escape panel has been fitted in the door to provide an exit through it in case of emergency."

With a view to meeting these requirements, a prewar manufacturer of packaging for launderers and dry cleaners cooperated with the Apex Railway Products Co. in the construction of an emergency escape hatchway. This assembly, which is designed to replace a cutout section in a door or bulkhead, consists of a round metal frame and 2 circular plates. While the construction of the frame was attended with few difficulties, the development of a satisfactory panel was a problem, since the objective was a plate which when backed up by a matching panel would withstand considerable steady pressure yet break out quickly when given a sharp blow.

In the course of experiments to discover a material which would meet the peculiar requirements of this "kick-out" panel, tests were made of a non-strategic thermoplastic material which had been developed on a pilot-plant scale about a year and a half before, and which had been used in the molding of experimental parts on a small converted injection press. As it happened this material company, while working toward the improvement of its plastics, was casting about for a manufacturer who would be interested in cooperating in

the development of a new type of injection equipment—a machine which would be specially designed to handle this new material on an economical basis.

According to the manufacturer of this new thermoplastic, application of the material to crown closures indicated that the absolute lack of cold flow in the plastic made it a satisfactory closure for beer. However, the problem which confronted the manufacturer at that time and which has since proved to be a stumbling block to the commercial application of the material to bottle caps, centers on the absence of a satisfactory method for softening the closures fast enough to permit standard capping equipment to operate at its usual high rate of speed.

Since the early, formative days, improvements have been made in the qualities of this plastic and in its method of manufacture. Tests made on panels molded of this material show that the parts meet all the following specifications set up for emergency escape hatches by the U. S. Maritime Commission, the U. S. Coast Guard and the Bureau of Marine Inspection and Navigation:

1. Material must not support combustion.
2. Material must not change formation in temperatures up to 200° F.
3. Material must not be affected by salt-spray moisture.
4. Water absorption shall not be unduly high. (Actual water absorption under test has been found to be 0.2 of 1 percent under 3 months' total submersion.)
5. Material must not be affected by salt-brine solution.
6. Minimum cold flow. (Tests at temperatures below 200° F. indicated no cold flow.) (Please turn to next page)

\* Registered U. S. Patent Office.

Two 6,000 watt oil immersion heating units

Injection cylinder

Heating system, pump and motor

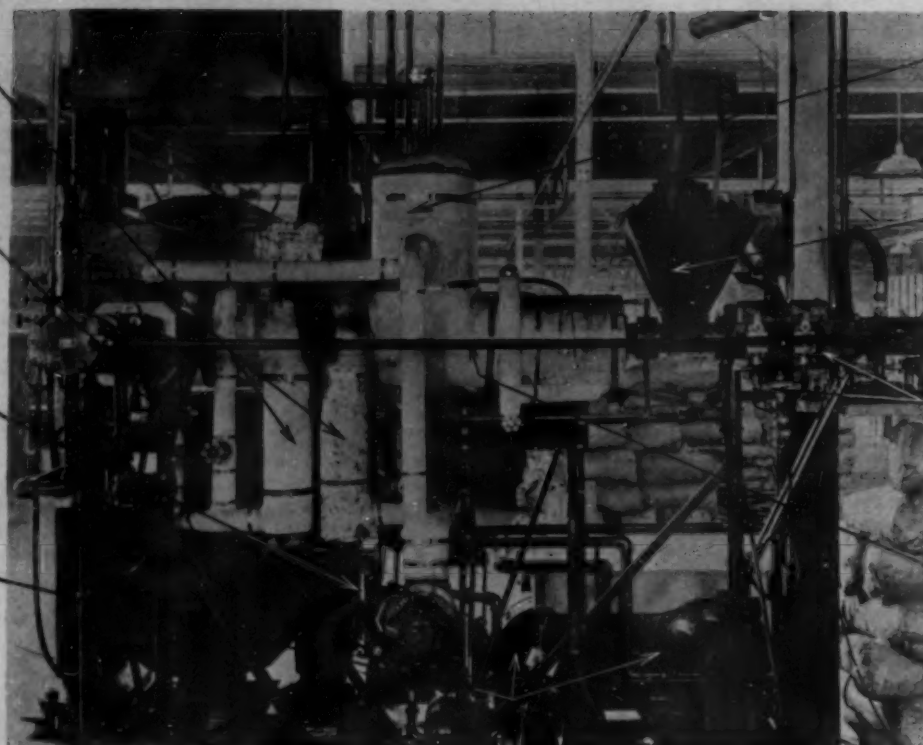
Two 30 G.P.M. hydraulic pumps and motors

Oil heating reservoir

Material hopper

Automatic hydraulic preheater feed system and electric controls

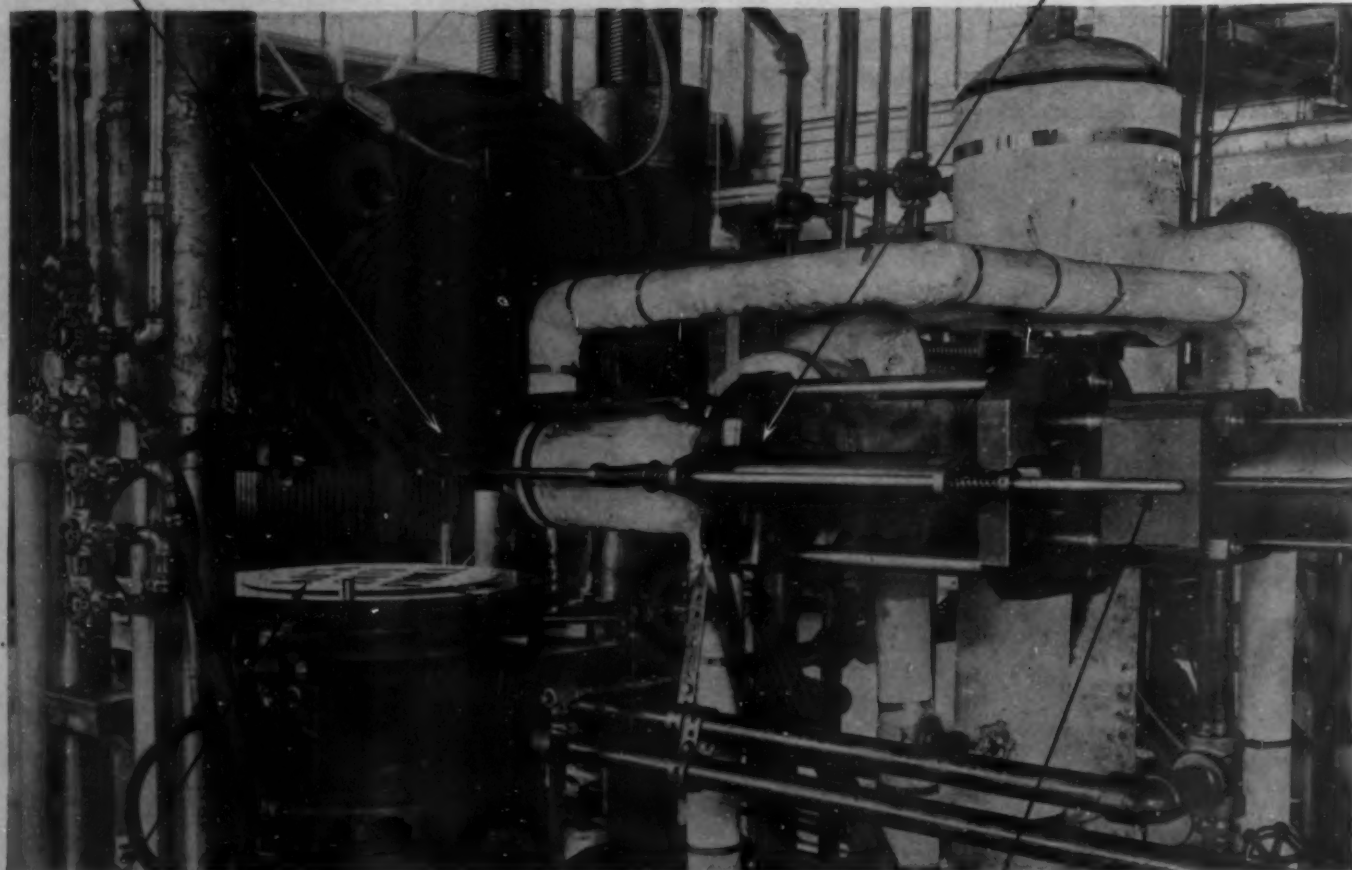
Main preheater tube



1

Injection cylinder nozzle

Injection plunger



Molded panel before removing from mold

Injection power cylinder

2

7. Molded panels must break clean without sharp or abrasive edges under an intensive blow.

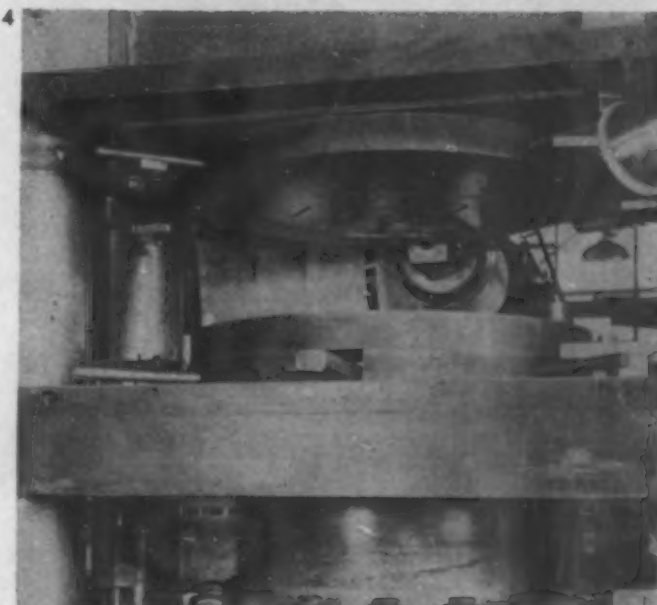
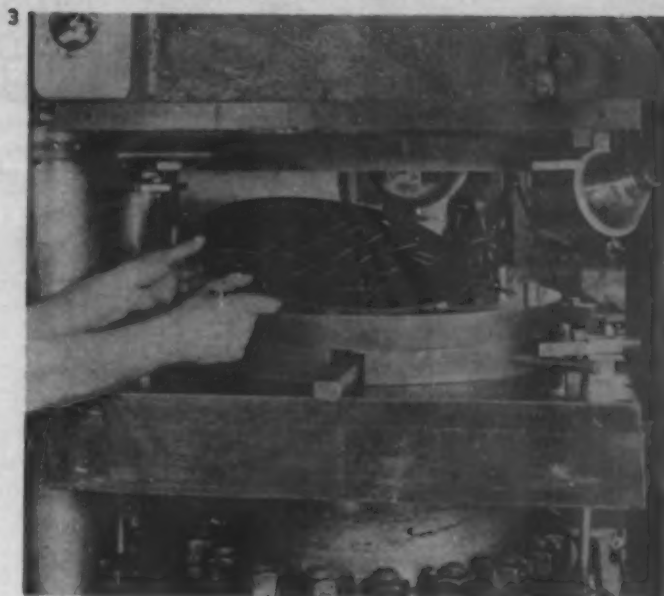
With the thermoplastic material established as having the properties necessary for this application, work was immediately started on the development of an injection machine sufficiently large to inject the amount of material necessary for the escape panel, which is  $18\frac{1}{4}$  in. in diameter and has a wall section of  $\frac{1}{32}$  inch. While the injection unit which was finally adopted is modest in size, it has a rated capacity of over  $3\frac{1}{2}$  lb. per minute. One of the factors limiting the volume of the material shot is the ability of the mold designer to core his mold so that the great amount of heat built up by the fast injection of such a large volume of material at elevated temperatures can be carried off and the mold thereby kept at a temperature low enough to chill each shot promptly.

This machine (Figs. 1 and 2) consists essentially of a large material pre-heater feeding into an injection cylinder which, in turn, furnishes the pressure necessary to fill out this large mold. All pre-heating and injection equipment used has been adapted to an 800-ton vertical press for clamping. The entire unit is self-contained and makes use of two 30 g.p.m. Racine pumps for pre-heater feed, injection and clamping pressure, and one small pump for circulating the heating oil. The oil-heating system employs two 6000-watt immersion units to heat the oil which is fed directly to the main pre-heater and the cored sections of the injection cylinder. A large hopper maintains sufficient material in reserve so that a supply is always available to the pre-heater feed. In order to eliminate oozing at the nozzle, an automatic shut-off valve is maintained in a closed position except at the exact moment of injection. This valve is necessary not only because of the free flowing qualities of the material but also because of the pressure which is exerted at all times upon the material in the injection chamber through the supply port. This port is held in an open position at all times except at the instant of injection.

Some details of the cycle are rather startling. The thermoplastic material used for the escape panel is held in the injection chamber at a temperature of  $448^{\circ}$  F. The speed of injection is very fast—the time for a 15-in. injection stroke and return being only 3 sec.—the injection plunger being returned immediately with no dwell required. This operating cycle indicates a very interesting feature with regard to the new material, namely, the very sharp break in the curve of plasticity vs. temperature. A drop of a very few degrees in the material temperature causes the plastic to harden almost instantly, so that the thin gate (which is all that is required in most cases) sets up and holds the material in the mold under pressure. It is possible for this thermoplastic to be held at elevated temperature (*Please turn to page 188*)

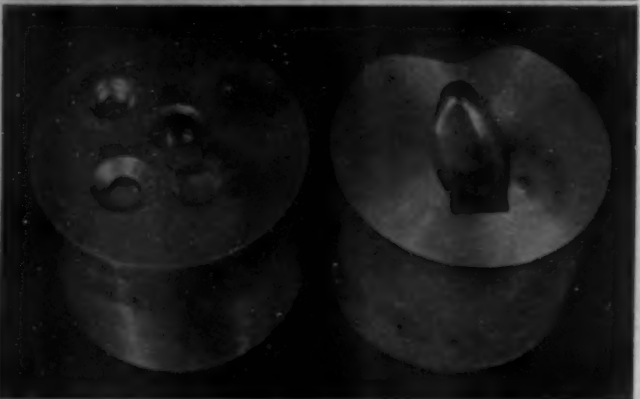
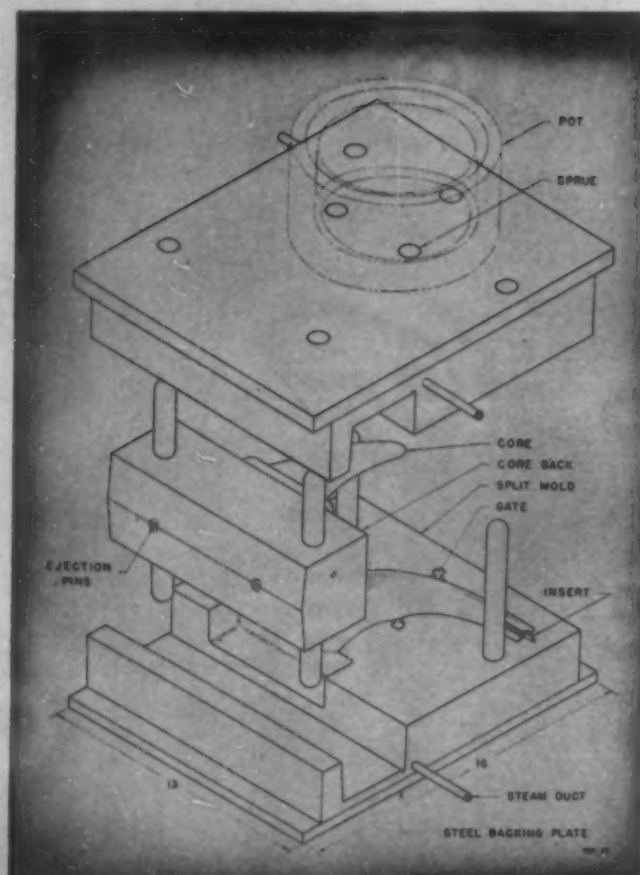
1 and 2—Two views of the  $3\frac{1}{2}$  lb. per min. injection machine. The handling of the large volume of material by this comparatively small machine was made possible by a complete departure from standard design. 3—One of the 268.65 sq. in. emergency escape panels is here being removed from the mold. The standard vertical compression press furnishes ample clamping pressure for the large molding area. 4—The word "kick-out" which appears on each panel is engraved on the mold. 5—Gate removal is the only finishing operation necessary on these pieces before they are packed for shipment. A complete unit consists of a metal ring and 2 panels

ALL PHOTOS IN THIS ARTICLE, COURTESY PHOENIX PRODUCTS CO.



# Economical tooling for aircraft parts\*

by CARROL C. SACHS†



**P**LASTIC materials, as they relate to airplane construction, possess many outstanding technically advantageous engineering properties and, as a result, are frequently specified for the production of aircraft parts. However, the number of moldings required for a particular airplane model is seldom sufficient to amortize the mold cost in a satisfactory manner. Frequently, initial requirements are for only one molding, and subsequent needs seldom exceed one thousand parts unless the particular molding is used in more than one installation on the airplane.

During the last two years, in an effort to develop plastic molds which were commensurate with production requirements, the possibility of using "soft" molding dies has received the careful consideration of various investigators. In May 1942, John Delmonte<sup>1</sup> described the experimental use of Kirksite for compression dies. Concurrently, our research laboratory became active in adapting this zinc-base alloy to various forms of molds other than the compression type. The object of the studies reported in the present article was, in part, to investigate the possibilities of using Kirksite as a substitute for steel in the development of more economical tooling for limited quantities of plastic parts.

Mold economy depends upon production and upkeep costs, and upon the quantity and quality of parts produced. Steel molds have long been accepted because of their low upkeep cost, long life and the good quality of the molded parts. While the original cost is usually quite high, the over-all cost is low if thousands of parts are made. In view of the comparatively small number of identical parts required in aircraft production, when steel molds are used the mold cost per part is high and the life of the mold has barely started when the production run is completed. Procurement of steel tooling from the standpoint of delivery has been a further impediment to the use of this metal.

## Transfer mold for hook antenna mast

With a view to reducing the original mold cost while maintaining a low upkeep cost, good quality and sufficient life for molding the required number of parts, it was decided to test the possibilities of Kirksite as a mold construction material. The physical properties and composition of this material are given in Tables I and II. In cooperation with the Coordinator of the Critical Materials Program, our company proceeded with the construction of a mold for the hook antenna mast used on the Lockheed Constellation airplane. While the construction of this mold was in no way to interfere with the production of the plane, the mold was to be used for production parts if completed in time and if the quality of the masts produced from it was satisfactory.

The walls of the hook antenna mast, a large molding (31 cu. in.) with a large core and insert, vary greatly in thickness—from  $\frac{1}{8}$  to  $1\frac{1}{2}$  inch. A macerated-filled molding requiring high pressure was specified for the part. The complexity of the mast made the part ideal for study since it would, if successful, allow a large number of other types of aircraft plastic parts to be made on the same type of tooling.

\* Presented before the Pacific Coast Conference of the Society of the Plastics Industry, Los Angeles, Calif., on Feb. 22, 1944.

† Laboratory research analyst, Lockheed Aircraft Corp.

<sup>1</sup> "Zinc Alloys for Molds," J. Delmonte, MODERN PLASTICS 19, 70, 108 (May 1942).

The procedure followed for the construction of the transfer mold was as follows:

1. A detailed drawing of the mold was prepared from the part print.
2. Master wood patterns of the core and the mast were made, and plaster splashes were prepared from these patterns.
3. From these plaster splashes and wood patterns, Kirk-site sand castings of the core and the two halves of the mold were made. Copper tubes were cast in each half of the mold to allow for steam heating if required.
4. The castings were then sent to the tooling department where they were scraped, machined, polished and fitted.
5. Molding tests were made.<sup>2</sup>

The mold was designed on the assumption that a top operating temperature of 350° F. and a maximum molding pressure of 10,000 p.s.i. would be encountered. The breakdown of the mold is shown in an exploded view in Fig. 1. Because of the coring, the insert and the variation in wall thickness in this part, the only feasible approach was through the use of the transfer molding method. The core had to be located in a definite position with regard to the mold cavity, since the core back was used as the mast base. This core placement resulted in high pressures against the core block during the molding operation. By locating the core back in a groove (Fig. 1) and using two steel pins through the back to the top and bottom steel plates, the position of the core was definitely fixed and considerable load could be taken by the guide pins to the steel plates.

The sprues were located 120° from a common center and were so gated that the material would flow to all parts of the cavity. By bringing the material in at the parting line of the

<sup>2</sup> Tests conducted through arrangements with McDonald Mfg. Co.

TABLE I.—PROPERTIES OF SAND-CAST KIRKSITE<sup>a</sup>

Ultimate shear strength, p.s.i.	45,800
Ultimate tensile strength, p.s.i.	37,800
Compressive strength, p.s.i.	60,000-75,000
Charpy impact strength (to break 1/4-in. bar), ft.-lb.	4
Brinell hardness number	100
Solidification shrinkage	0.14
Melting point, ° F.	717
Weight, cu. in., lb.	0.25
Weight, cu. ft., lb.	432
Elongation in 2 in., %	3
Coefficient of linear expansion, ° F.	15.4 × 10 <sup>-6</sup>

<sup>a</sup> From "Kirk-site 'A' Handbook," Morris P. Kirk and Son, Inc.

TABLE II.—COMPOSITION OF KIRKSITE-A<sup>a</sup>

	%
Zinc	93.17
Aluminum	4.10
Copper	2.70
Magnesium	0.03

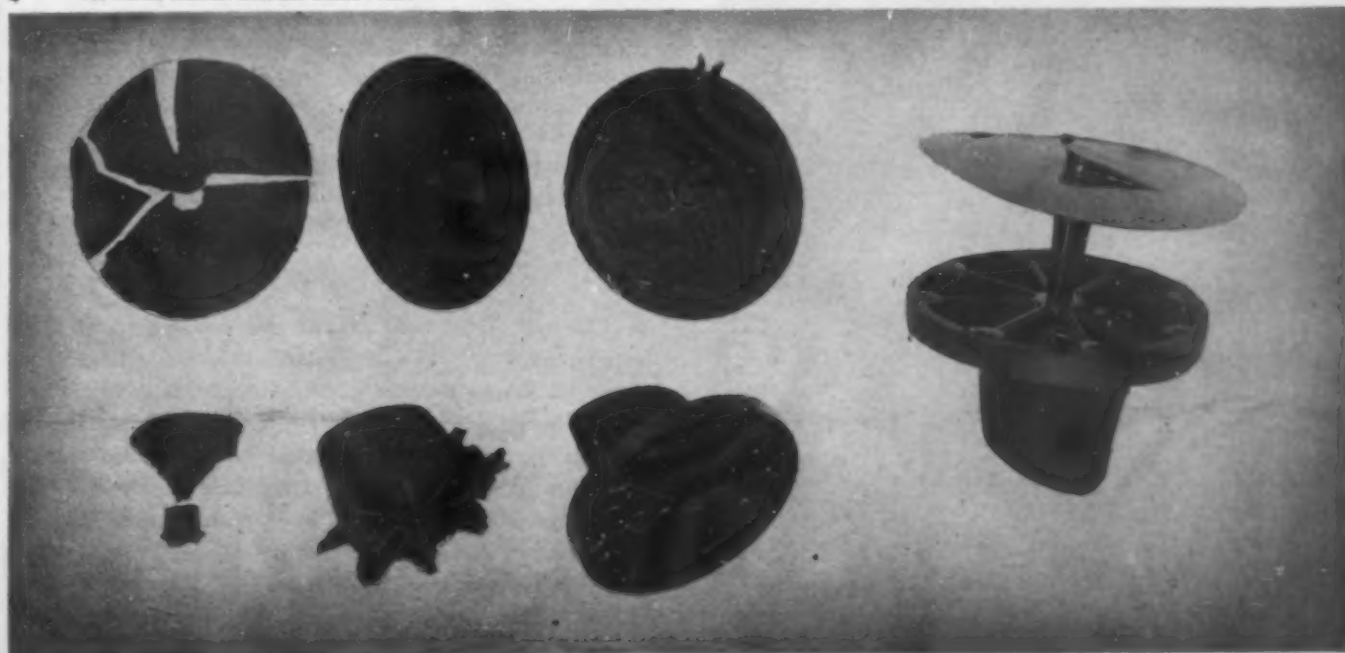
<sup>a</sup> From "Tool Design Standards," Section 2.630, Lockheed Aircraft Corp.

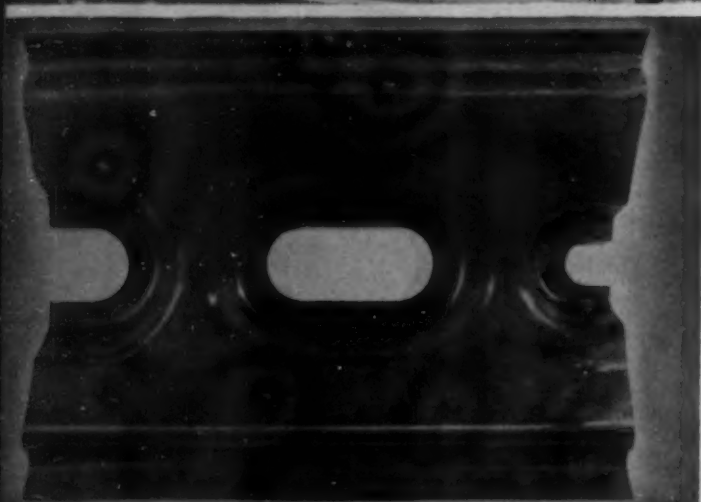
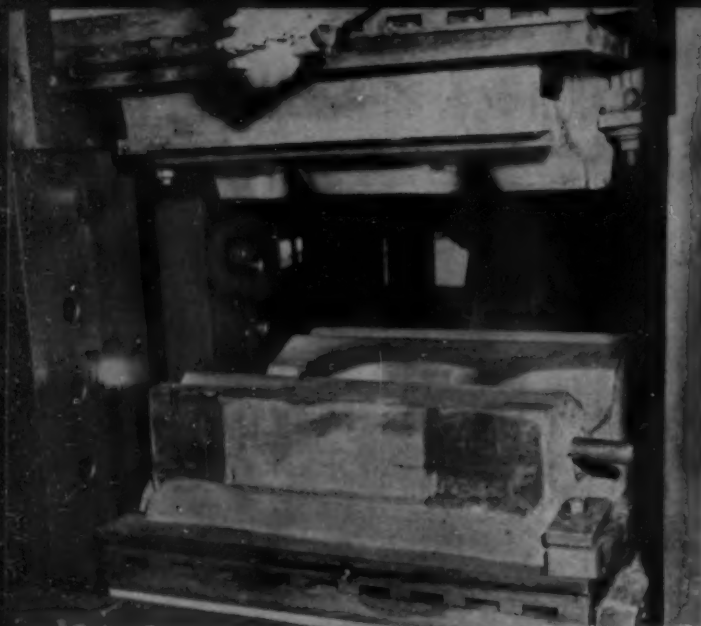
mold, there was very little force tending to deflect the core or to shear the insert. This arrangement also facilitated the finishing of the molded part. Since the mold was quite bulky, steam was not circulated through the copper tubing cast into the die. All heating was accomplished by heat transfer from the hotplates in the press.

The greatest difficulty experienced in the construction of

1—An exploded view of the mold used in the production of the hook antenna mast. 2—A mast as it appears upon ejection from the mold. 3—The cavities at the left were hobbled at room temperature. The cracks are due to insufficient elongation of the metal. The cavity of a razor case (right) was hobbled at 350° F. The increased ductility of the metal is indicated by near absence of cracks. 4—The pieces (left to right) are the result of a series of moldings in which successively larger charges of powder were used and show the sequence in which the various parts of the mold fill out. The result of the full 250-gr. shot is shown at the extreme right. The sample at the left indicates that the bulk of the material merely falls into the mold cavity when a 50-gr. charge is used. A 100-gr. charge (second from left) appears to fall partially into the mold cavity where it cures in contact with the fallen material

4 ALL PHOTOS, COURTESY LOCKHEED AIRCRAFT CORP.





5 the mold was due to the porosity of the cast material in the region of the cavity. Although new Kirksite was specified, it was later found that remelt had been used and this, undoubtedly, was partly responsible for the trouble.

A later investigation was conducted casting Kirksite into Antioch plaster molds. Outstanding advantages in comparison with zinc-alloy castings produced in sand molds, were a substantial improvement in the surface smoothness and a freedom from pits, entrainments of sand and blow holes.

Surface imperfections which were uncovered when the cavity was scraped during finishing were repaired by one of two methods: 1) by preheating the die and welding the pitted area, and then rescraping, or 2) by drilling the pitted area so that it could be plugged with Kirksite wire. This latter method was applied after most of the machining was complete, to avoid the possibility of warping the die, a condition which might occur if the first method were employed. Several adjustments had to be made in the mold to correct the difference in the thermal coefficients of expansion of the steel plate, the steel pins and the zinc-alloy casting. In addition, the "pot" was modified so that it would be definitely located with respect to the sprues.

After the above modifications were completed, the mold was again placed in the press and satisfactory parts were molded. A relatively soft-flow phenol-formaldehyde material (Bakelite #120 and #6012—one-half of each) was used very successfully. However, when a macerated cloth-filled phenolic was used—as originally contemplated—the size of the gates was found to be inadequate. When the gates were enlarged, the flow was found to be satisfactory. Actually, subsequent physical tests proved the macerated mast to be weaker in tension and bending—in this case the critical type of loading.

6 The plastic parts as they appeared on ejection from the mold are shown in Fig. 2. These moldings were satisfactory both in appearance and functional strength and, up to the present time, approximately 80 plastic antenna masts have been molded. Careful measurements indicate that the dimensions of the Kirksite mold cavity have not changed as a result of this limited molding, and no degradation of the surface of the cavity was discernible.

#### Die-sinking of zinc alloy by hobbing

After the establishment of the suitability of Kirksite for the construction of transfer molds, a further study was made to determine the hobbing characteristics of this zinc alloy. Hobbing is a process of forming a mold cavity by forcing a hardened steel master of the same shape as the molded object into a softer cavity blank which may be subsequently trimmed, fitted to a chase, hardened and polished.

The hob, of a heat treatable alloy such as K-46 steel,<sup>8</sup> is

<sup>8</sup> Jamison Steel Co.

7 5—The zinc-alloy mold used in test molding of the inner skin samples. 6—The illustration at the top shows the appearance of the front of an inner skin frame, laminated-molded from material D, after trimming and routing. At the bottom is a view of the same inner skin frame prior to trimming. 7—An inner skin frame laminated from impregnated P-18 Army boot duck, material A. The folding, tearing and disintegration of the fabric filler in certain areas occurred because of insufficient elongation and flow. It is believed that this part could be laminated quite successfully from double-creped fabric

made to the dimensions of the part to be molded, material shrinkage being added. The finished hob is given a high polish after hardening, and the quality of the polishing is reflected in the finish of the hobbled cavity. For purpose of lubrication, the hob is generally copper plated by simple immersion in a solution of blue vitriol (copper sulfate).

Hobs representing the proposed stub antenna mast for a new version of the Lockheed Lightning soon to be released, were produced in order to determine the requisite conditions for applying the hobbing technique to Kirksite. Because of the narrow, deep shape of this part it would be extremely difficult to machine the female cavity for molding. The alternative to hobbing—a split-cavity mold with attendant problems of coordination of the mating portions of the die—would result in a high die cost and additional finishing.

Since the hobbing press required for the experimental die-sinking of zinc alloy was not available at Lockheed, the offer by a West Coast molder<sup>4</sup> of the use of a 1500-ton press, and assistance in the actual hobbing operations, was accepted. The procedure employed to determine the hobbing qualities of Kirksite was as follows:

1. A detailed drawing was prepared for the airplane stub antenna mast.

2. A wooden pattern of the mast was produced from the detailed part drawing by the pattern shop.

3. The hob was produced from the wooden pattern using a Keller duplicator. The hob, formed from K-46 steel, was given a preliminary polish, heat-treated to 57-C Rockwell and then given a final polish.

4. A suitable hobbing chase, 12-in. O.D., 6-in. I.D. by 6-in. thick, was produced in the laboratory machine shop. The inside diameter was slightly tapered.

5. Billets of zinc alloy were obtained in the "as-cast" condition. An attempt was made to obtain an equal number of "forged" billets. However, the facilities required for the forging operation were not available locally.

6. The cavity blanks of Kirksite were hobbled at room temperature (75° F.) and at 350° F.

7. The first hob was broken early in the experiments. The tests were momentarily continued, using several obsolete hobs. Cavities produced from the hobs are shown in Fig. 3.

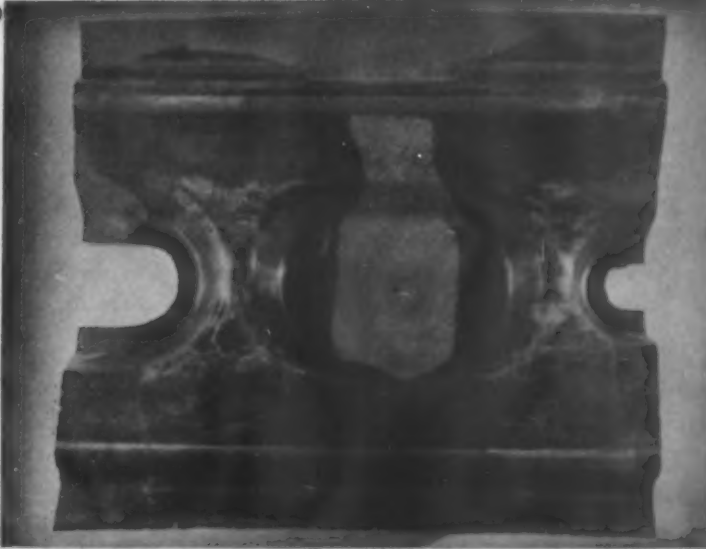
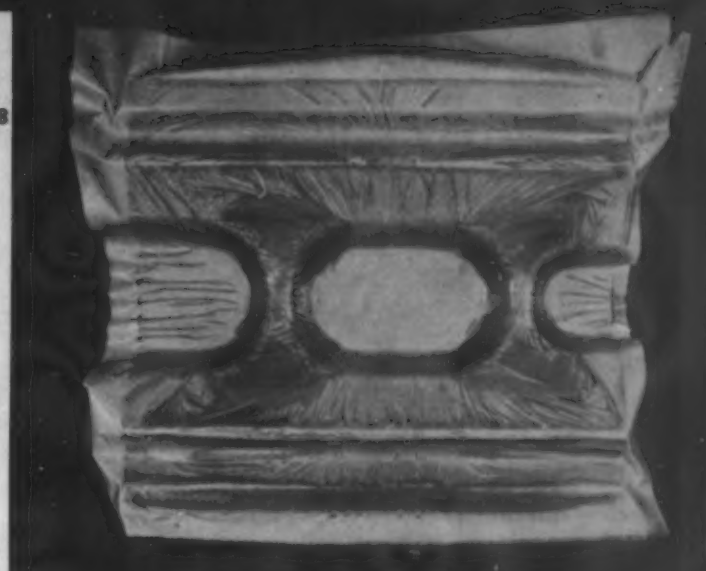
8. A second hob was subsequently produced, identical in all respects to the original hob, except that the groove in the end of the hob was eliminated.

9. A successfully hobbled cavity was obtained. This cavity block was trimmed to size and mounted along with suitable accessories.

10. After successful parts had been molded, a series of underweight shots were made to determine the nature of the flow characteristics of this design (Fig. 4).

As a result of these tests, it was observed that the poor

<sup>4</sup> F. E. Reinhold Co.



8—In this inner skin frame, laminated-molded from material B, two facts are evident: 1) practically no flow or elongation and 2) considerable segregation of resin in the critical areas. 9—This part, laminated from material C, shows how wrinkles form in paper mat when filler material is neither creped nor impregnated. 10—White areas in center cup of this frame which was laminated from material E were caused by improper breathing of the mold. 11—A skin frame made up of material B in the outer skin and E in the inner skin. Cold-setting, contact-pressure cement was used in the assembly

ductility and low elongation of cast-zinc alloy make hobbing impractical at room temperature. Even at the elevated temperature of 350° F., the zinc alloy does not flow by displacement to an appreciable extent. This was apparent when it was observed that the relief holes drilled into the bottom of the zinc-alloy billet failed to extrude full of the material displaced by the hob. Whereas such relief holes would be entirely filled if annealed alloy steel were used, in the case of Kirksite, the relief holes were hardly out of round. This would lead to the conclusion that considerable forging action had occurred during the hobbing—a conclusion which was partly confirmed by the high-pitched ring which resulted when the cavity block was tapped with a ball hammer. The density of the material comprising the cavity proper appeared to be greater, and the material was definitely harder and more scratch resistant than as-cast zinc alloy. This forging property corresponds to the heat treatment generally given steel cavity blocks after hobbing and probably consists of a combination of forging action and work hardening.

It was also observed that at 350° F., Kirksite showed a marked decrease in the tendency to tear and crack during the hobbing operation. In contrast, the cavities shown at the left in Fig. 3 were hobbled at room temperature and show tearing of the zinc alloy.

No difficulties were encountered in obtaining satisfactory flow of the molding material from the transfer pot through the sprue and into the mold cavity. The flow characteristics, as ascertained by a series of underweight shots pictured in Fig. 4, indicate that the bulk of the material merely falls into the mold cavity when a 50-gr. charge is used. A 100-gr. charge appears to fall partially into the mold cavity where it cures in contact with the fallen material. This amount of material substantially fills the mast portion of the cavity. However, little or no back pressure has been developed as yet, since the molding is granular in nature. A 150-gr. charge fills the mast portion of the cavity and initiates the filling of the webs and face of the base. It should be noted that the tip of the mast is still granular although sufficient back pressure has existed in the narrow webs to consolidate the molding compound. Two hundred grams in the charge fill the entire cavity with the exception of the ring around the periphery. In this case, the pressure has reverted into the

mast cavity and consolidated the tip, removing the granular appearance. Since the material is thermosetting in nature, it continues to cure as it flows in the mold. This explains why back pressure rises rapidly as the cycle progresses. A full shot consisted of a 250-gr. molding powder charge, and satisfactory flow was obtained to fill the mold cavity completely before the cure advanced sufficiently to enhance the plasticity. After the cavity was entirely full, the positive nature of the transfer-type mold caused a fluid pressure of about 1600 p.s.i. on the molding compound which sufficed to consolidate the material completely and insure intimate contact with the mold cavity surface.

Zinc alloy has been found suitable for hobbing and may be specified as interchangeable with alloy hobbled steels where, as in aircraft, production requirements are light. Several definite conclusions can be enumerated as a result of this study:

1. Zinc alloy forges satisfactorily at 350° F. although too little ductility and elongation is present at room temperature. Satisfactory displacement, which increased with the depth which was hobbled, occurred at 3500–4500 lb. p.s.i.
2. After fitting to a steel mold chase, the zinc-alloy cavity block satisfactorily sustained the pressures developed in the transfer molding cycle.
3. Hobbed Kirksite, by virtue of its forging (non-flowing) characteristics, becomes much harder, scratch-resistant and capable of withstanding molding pressures.
4. Zinc alloy in plastic molds has the unique property of non-adhesion between itself and any of the phenol-formaldehyde, urea-formaldehyde or phenol-furfural molding compounds tested to date. This circumstance is very advantageous in contrast to the frequent sticking which is experienced in steel- or chrome-plated steel molds.

#### Laminating mold for inner skin door frame

With the increasing use of laminated plastic parts in the airplane, it has been more or less accepted that the use of phenolic, urea, melamine and furfural resins is necessarily accompanied by a high tool cost which results from the use of steel dies. It has already been demonstrated that Kirksite possesses sufficient life for the transfer molding of the limited number of parts generally re- (Please turn to page 178)

12—The inner skin frame, molded of material D, and the outer skin, molded of a high-strength laminated material, were assembled with a cold-setting, contact-pressure cement. 13—Inability of material F to flow explains the appearance of this inner skin frame. Deep draws are impossible with this material because of its low tensile strength





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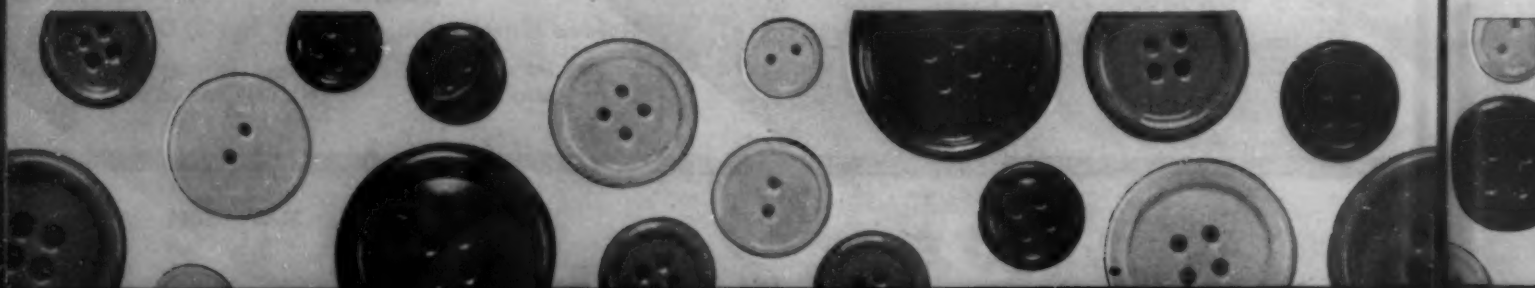
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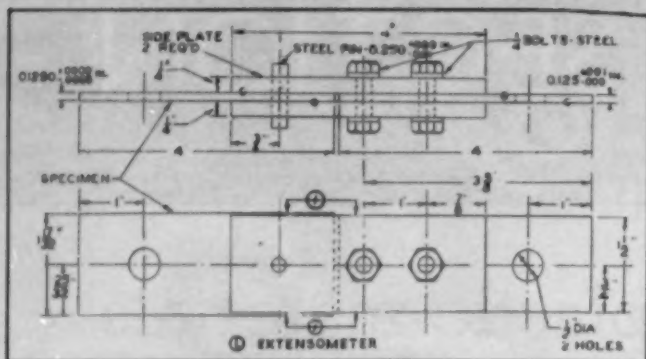
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## by R. T. SCHWARTZ and EDWARD DUGGER, JR.\*

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4—A bearing test jig of the wide type. It should be noted with reference to this figure that: 1) the material is steel, heat treated to Rockwell C35-40, 2) machine finish after heat treatment, 3) G indicates the grind surfaces and 4) all dimensions are given in inches and the tolerance on all fractions is  $\pm 1/64$

TABLE I.—DESCRIPTION OF PLASTIC MATERIALS

Type of plastic	Specific gravity	Description
<b>THERMOSETTING</b>		
Phenolic laminate, Grade L	1.34	Fine-weave cotton fabric, parallel-laminated sheet; Fed. Spec. HH-P-256
Phenolic laminate, Grade C	1.34	Coarse-weave cotton fabric, parallel-laminated sheet; Fed. Spec. HH-P-256
Phenolic laminate Grade XX	1.34	Paper-base parallel-laminated sheet; Fed. Spec. HH-P-256
Phenolic laminate, high-strength paper	1.40	High-strength paper, cross-laminated sheet
Resin-impregnated compressed maple	1.36	Phenolic-resin-impregnated, parallel-laminated compressed maple; AAF Spec. 15065
Allyl resin low-pressure glass-fabric laminate	1.06	Plain-weave glass fabric, cross-laminated
Lignin laminate	1.39	Paper-base, parallel-laminated; lignin resin
Lignin laminate, phenolic paper-base faces	1.39	Paper-base, parallel-laminated; lignin resin
<b>THERMOPLASTIC</b>		
Cellulose acetate	1.28	Transparent sheet; AAF Spec. 12025-B
Cellulose acetate H3	1.31	Opaque molded sheet; Rockwell M hardness 65-68
Cellulose acetate H5	1.31	Opaque molded sheet; Rockwell M hardness 79-82
Cellulose acetate butyrate H1	1.10	Opaque molded sheet; Rockwell M hardness 51-54
Cellulose acetate butyrate H5	1.20	Opaque molded sheet; Rockwell M hardness 67-70
Polymethyl methacrylate	1.18	Cast transparent sheet; U. S. Army Spec. 94-12014-B
Polyvinyl chloride acetate	1.35	Transparent sheet
Polystyrene	1.05	Molded transparent sheet

and description of which are given in Table I. The nominal thickness of the majority of the sheets was  $1/8$  in., but some  $1/16$  in. thick material was also tested. The H1, H3 and H5 designations of the cellulose acetate and cellulose acetate butyrate molded materials refer to the relative hardness and flow characteristics of the materials. Rockwell M hardness of these materials was determined according to Federal Specification L-P-406.

#### Test procedure

The test specimen (Fig. 1) is used as the center plate in a 3-plate jig (Figs. 2 and 3) employing hardened steel pins to provide the bearing load—the jig being loaded in tension. The standard test specimen is 0.938 in. wide— $1/8$  in. nominal thickness—with a 0.250-in. diameter bearing hole and an edge distance of 2.5 times the diameter. This width of specimen was adopted for the narrow jig so that standard autographic gages as well as Tuckerman optical-strain gages could be used. If 4 percent deformation was not reached before failure, other tests were made using a diameter of 0.125 in. and an edge distance of 5 times this diameter. However, before the above standard procedure was adopted, a wider jig and specimen were used (Fig. 4).

The specimen is slightly wider than the jig so as to permit the mounting of extensometers. The deformation is measured, as indicated in Fig. 2, between points on a line with the loaded edge of the hole and points in the jig. Any deformation of the pin is included in this measurement, but it is usually negligible unless bending of the pin occurs as on small diameter pins in thick specimens. The thickness of the steel spacer plate is adjusted by shims so that the bearing specimen fits the jig to within 0.005 in., and no appreciable force is required to pull the specimen out of the jig when the steel pin is removed.

The tests were made in a hydraulic testing machine of 20,000 lb. capacity, adjusted to a suitable scale range. Templin self-aligning grips were employed to hold the jig loaded in tension. Deformation was measured with paired Tuckerman optical-strain gages, 1 in. gage length, mounted opposite each other, although a few tests made with a Templin autographic strain gage and recorder gave results comparable to those obtained with the Tuckerman gages.

Using Tuckerman gages, even loading was obtained by first applying a small increment of load and then reading both gages. If the readings were not equal, the loading apparatus was adjusted until even loading was obtained. The deformation curve was then determined. Simultaneous readings of load and deformation were taken until 4 percent deformation of the hole diameter was reached, at which point the strain gages were removed and the specimen loaded to failure. The rate of head travel under load did not exceed 0.05 in. per minute.

The loads were converted to bearing stresses by dividing them by the bearing area, i.e., the diameter of the hole times the thickness of the specimen. Bearing stress at which the bearing hole was deformed 4 percent of its diameter, was determined from the curve of bearing stress plotted against deformation; ultimate bearing stress was calculated from the maximum load sustained by the specimen. Edge distance ratio, as given in Tables II and III, is the distance from the edge of the specimen to the circumference of the bearing hole divided by the diameter of the hole.

All specimens were conditioned for 48 hr. at  $77 \pm 2^\circ$  F. and  $50 \pm 2$  percent relative humidity before testing. The laboratory humidity conditions could not be controlled, but all specimens were tested in the laboratory at  $77 \pm 2^\circ$  F. and

TABLE II.—BEARING PROPERTIES<sup>a</sup> OF VARIOUS THERMOSETTING PLASTICS AT 77 ± 2° F.

Type of plastic	Thickness, average	Direction of specimen and loading	Diameter of hole	Width of specimen <sup>b</sup>	Edge distance ratio	Bearing stress at deformation of 4 percent of hole diameter	Bearing stress at ultimate	Ultimate load	Ultimate load divided by net tensile area
	in.		in.			p.s.i.	p.s.i.	lb.	p.s.i.
Grade L phenolic laminate	0.126	crosswise	0.250	A	2.5	18,600	27,400	865	5,400
		lengthwise	0.250	A	2.5	20,300	28,900	910	5,600
		lengthwise	0.250	B	2.5	20,000 <sup>c</sup>	23,600	710	8,200
		lengthwise	0.250	A	1.0	15,000	20,800	655	4,100
		lengthwise	0.125	A	2.5	17,700	36,500	575	3,300
		lengthwise	0.125	A	5.0	19,100	57,100	900	5,100
		lengthwise	0.0625	A	2.5	12,400	45,000 <sup>d</sup>	300	1,900
		lengthwise	0.0625	A	5.0	11,300 <sup>e</sup>	..	..	..
	0.061	lengthwise	0.250	A	2.5	19,800	29,100	440	5,700
Grade C phenolic laminate	0.125	crosswise	0.250	A	2.5	20,400	28,200	880	5,500
		lengthwise	0.250	A	2.5	20,800	25,300	790	5,000
		lengthwise	0.250	B	2.5	21,700	22,700	710	8,300
Grade XX phenolic laminate	0.125	crosswise	0.250	A	2.5	23,800	26,600	780	4,900
		lengthwise	0.250	A	2.5	23,200	23,800	745	4,700
		lengthwise	0.250	B	2.5	17,700 <sup>f</sup>	22,100	690	8,000
High-strength paper phenolic laminate	0.125	...	0.250	B	2.5	21,200 <sup>f</sup>	25,000	780	9,100
		...	0.250	A	2.5	22,300 <sup>f</sup>	25,800	805	5,000
		...	0.125	B	5.0	31,100	33,000	520	5,100
Resin-impregnated compressed maple	0.125	lengthwise; parallel to grain	0.250	B	2.5	19,600 <sup>f</sup>	22,100	690	8,000
		lengthwise	0.125	B	10.0	24,500	34,200	540	5,300
Allyl glass-fabric laminate	0.145	...	0.250	B	2.5	17,300	30,600	1110	11,100
Lignin laminate	0.129	lengthwise	0.250	B	2.5	17,500 <sup>f</sup>	18,900	610	6,900
Lignin laminate, phenolic paper base	0.137	lengthwise	0.250	B	2.5	18,000 <sup>f</sup>	20,100	650	7,400

<sup>a</sup> Values are averages for 2 to 5 specimens.<sup>b</sup> A indicates 1.531 in. width specimen; B indicates 0.938 in. width specimen.<sup>c</sup> Autographic recorder used.<sup>d</sup> The 1/16 in. pin bent considerably at higher stresses, necessitating the making of a new pin. Therefore, most tests made with this pin were not carried to ultimate.<sup>e</sup> One specimen.<sup>f</sup> Stress at 2 percent deformation of hole diameter. Failure occurred before 4 percent deformation was reached.TABLE III.—BEARING PROPERTIES<sup>a</sup> OF VARIOUS THERMOPLASTIC MATERIALS AT 77 ± 2° F.

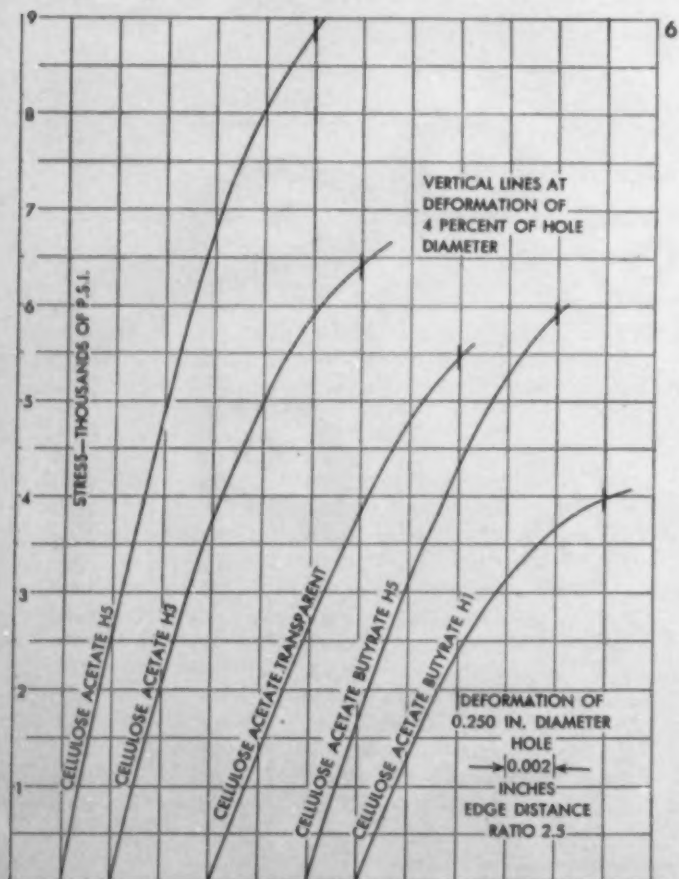
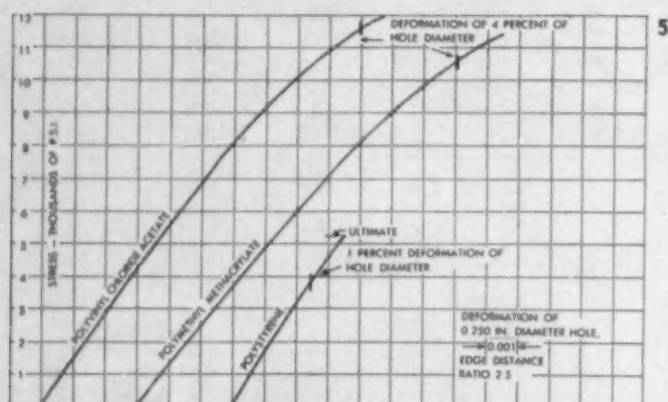
Type of plastic	Thickness, average	Width of specimen <sup>b</sup>	Diameter of hole	Edge distance ratio	Bearing stress at deformation of 4 percent of hole diameter	Bearing stress at ultimate	Ultimate load	Ultimate load divided by net tensile area
	in.		in.		p.s.i.	p.s.i.	lb.	p.s.i.
Cellulose acetate, transparent	0.131	B	0.250	2.5	6,600	14,500	475	5300
	0.131	A	0.250	2.5	5,400	15,500	505	3000
	0.131	A	0.250	1.0	3,900	9,300	305	1800
	0.063	A	0.250	2.5	5,500	15,300	240	3000
	0.131	A	0.125	2.5	4,600	16,800	550	3000
	0.131	A	0.125	5.0	5,400	23,300	760	4200
	0.128	B	0.250	2.5	6,900	14,800	475	5400
Cellulose acetate H3	0.125	B	0.250	2.5	8,800	19,600	620	7200
Cellulose acetate butyrate H1	0.110	B	0.250	2.5	4,000	10,900	300	4000
Cellulose acetate butyrate H5	0.121	B	0.250	2.5	5,900	15,600	470	5700
Polymethyl methacrylate	0.128	B	0.250	2.5	11,300	21,100	650	7700
	0.128	A	0.250	2.5	10,500	18,700	625	3700
Polyvinyl chloride acetate	0.125	A	0.250	2.5	11,600	22,600	705	4400
Polystyrene	0.129	B	0.250	2.5	4,000 <sup>c</sup>	5,500	180	2000

<sup>a</sup> Values are averages for 2 to 5 specimens.<sup>b</sup> A indicates 1.531 in. width specimen; B indicates 0.938 in. width specimen.<sup>c</sup> Stress at 1 percent deformation of hole diameter. Failure occurred before 4 percent deformation was reached.

at 35 to 65 percent humidity immediately after removal from the conditioning atmosphere. A few tests were also made on  $1/16$  in. thick material, on specimens with hole diameters of 0.125 and 0.0625 in., and on specimens with various edge distance ratios.

Tensile strength was determined on the same sheet of material from which the bearing specimens were taken. Compressive strength was determined on specimens taken in most cases from  $1/2$  in. thick sheet of the same material, the properties of which were practically the same as the thinner sheet. For transparent cellulose acetate, polyvinyl chloride acetate and allyl glass-fabric laminate, the compressive strength was determined on specimens cut from  $1/8$  in. thick sheet. Tensile and compressive test specimens and procedures were in accordance with Federal Specification L-P-406. All compressive specimens were edgewise and had a slenderness ratio of fourteen.

**5—Bearing stress-deformation curves of various thermoplastic 1/8-in. sheet materials. 6—Bearing stress-deformation curves of cellulose plastic, 1/8-in. sheet. 7—Bearing stress-deformation curves of laminated phenolic sheet material, 1/8-in. thick. 8—Bearing stress-deformation curves of various laminated thermosetting materials, 1/8-in. thick**

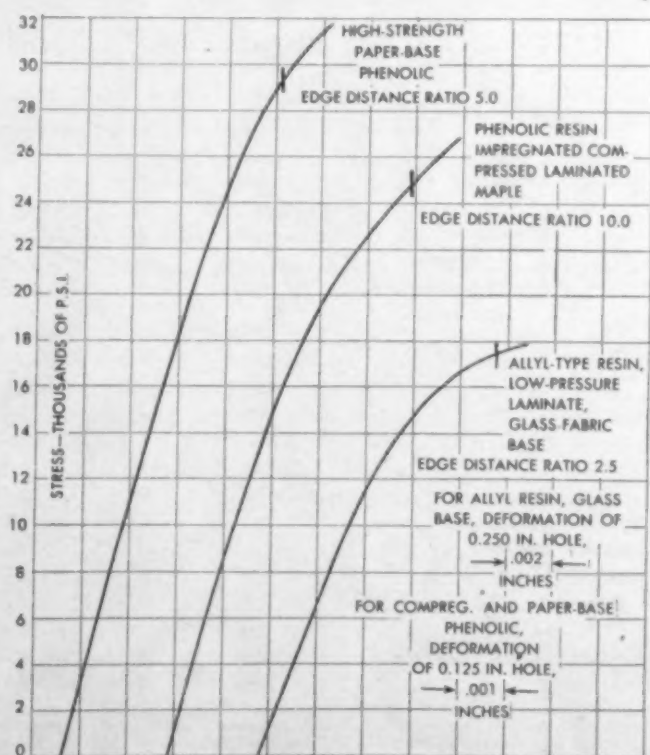
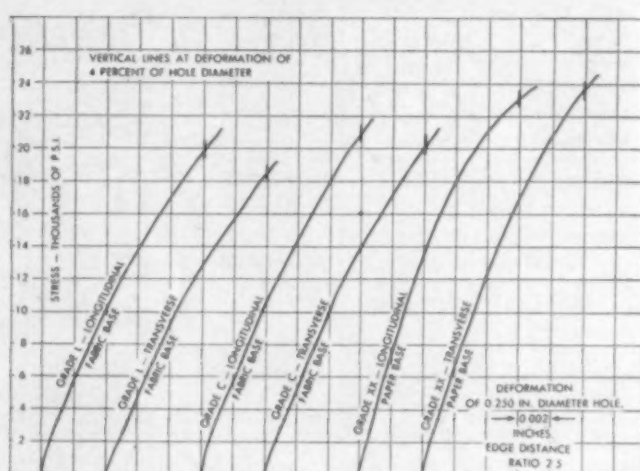


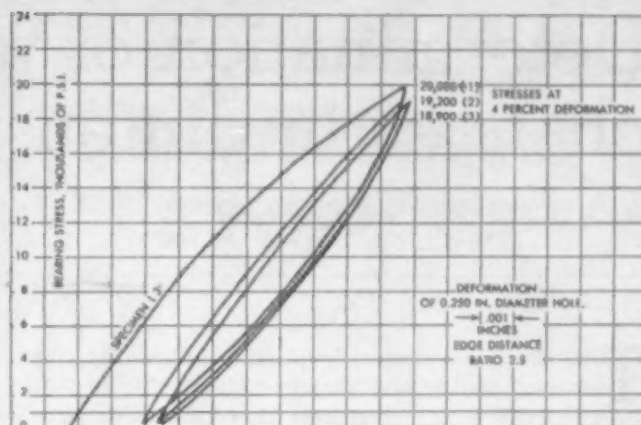
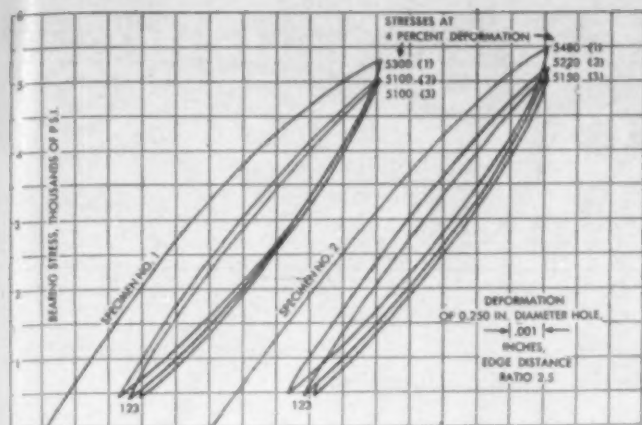
## Bearing properties

Results of the bearing tests are given in average values in Tables II and III, the maximum deviation being approximately  $\pm 5$  percent. Typical bearing stress-deformation curves for various materials are shown in Figs. 5 to 8, and hysteresis curves in bearing are given in Figs. 9 and 10. A comparison of bearing strength with tensile and compressive strengths can be found in Tables IV and V.

The bearing stress, calculated from the load by dividing by the diameter of the hole times the thickness, is a fictitious stress which does not necessarily represent the actual average stress occurring, and probably does not. However, this is of little consequence since allowable loads are calculated from the empirically determined allowable stresses by the same formula, which is standard.

The definition of bearing strength proposed for plastic material is the bearing stress (Please turn to page 180)





9—Bearing stress-deformation curves, repeated loading of transparent cellulose acetate sheet, 1/8 in. thick. 10—Bearing stress-deformation curves, repeated loading, of phenolic laminate, Grade L, cotton fabric, lengthwise, 1/8 in. thick

TABLE IV.—COMPARATIVE TENSILE, COMPRESSIVE AND BEARING STRENGTHS OF VARIOUS THERMOSETTING PLASTICS. AVERAGE VALUES, AT  $77 \pm 2^\circ \text{F}$ .

Type of plastic	Thickness, average	Direction of specimen and loading	Bearing stress at deformation of 4 percent of hole diameter <sup>a</sup>	Tensile strength	Compressive strength	Ratio of bearing stress at 4 percent deformation to:	
						Tensile strength	Compressive strength
	in.		p.s.i.	p.s.i.	p.s.i.		
Grade L phenolic laminate	0.126	crosswise	18,600	12,500	24,700	1.49	0.71
	0.126	lengthwise	20,300	18,900	25,800	1.07	0.79
	0.061	lengthwise	19,800	16,500	25,800	1.20	0.77
Grade C phenolic laminate	0.125	crosswise	20,400	9,600	27,500	2.12	0.74
	0.125	lengthwise	20,800	14,700	27,800	1.41	0.75
Grade XX phenolic laminate	0.125	crosswise	23,800	14,600	23,400	1.63	1.02
	0.125	lengthwise	23,200	16,800	23,800	1.38	0.97
High-strength paper phenolic laminate	0.125	...	31,100	25,000	22,400	1.25	1.39
Resin-impregnated compressed maple	0.125	lengthwise	24,500	32,900	27,700	0.74	0.88
Allyl glass-fabric laminate	0.145	lengthwise	17,300	27,700	9,400	0.63	1.84
Lignin laminate	0.129	lengthwise	17,500 <sup>b</sup>	11,100	17,300	1.59	1.01
Lignin laminate, phenolic paper base	0.129	lengthwise	18,000 <sup>b</sup>	12,000	13,800	1.50	1.31

<sup>a</sup> For test conditions, see Table II.

<sup>b</sup> Stress at 2 percent deformation. Failure occurred before 4 percent deformation was reached.

TABLE V.—COMPARATIVE TENSILE, COMPRESSIVE AND BEARING STRENGTH OF VARIOUS THERMOPLASTIC MATERIALS. AVERAGE VALUES, AT  $77 \pm 2^\circ \text{F}$ .

Type of plastic	Thickness, average	Bearing stress at deformation of 4 percent of hole diameter <sup>a</sup>	Tensile strength	Compressive strength	Ratio of bearing stress at 4 percent deformation to:	
					Tensile strength	Compressive strength
	in.	p.s.i.	p.s.i.	p.s.i.		
Cellulose acetate, transparent	0.131	5,400 <sup>b</sup>	5600	7,300	0.96	0.74
	0.063	5,500	5900	7,300	0.93	0.75
Cellulose acetate H3	0.128	6,900	6400	5,900	1.08	1.17
Cellulose acetate H5	0.125	8,800	7400	8,700	1.19	1.01
Cellulose acetate butyrate H1	0.110	4,000	4900	4,500	0.82	0.89
Cellulose acetate butyrate H5	0.121	5,900	6500	6,500	0.91	0.91
Polymethyl methacrylate	0.128	10,500	8100	11,900	1.30	0.88
Polyvinyl chloride acetate	0.125	11,600	9400	12,400	1.23	0.94
Polystyrene	0.129	4,000 <sup>c</sup>	3700	15,200	1.08	0.26

<sup>a</sup> For test conditions see Table III.

<sup>b</sup> Width of specimen 1.531 in.; diameter of hole 0.250 in.; edge distance ratio 2.5.

<sup>c</sup> Stress at 1 percent deformation. Failure occurred before 4 percent deformation was reached.

# Determination of water absorption by changes in dimensions

by JOHN DELMONTE\* and LOUIS ASSELIN\*\*

THE absorption of water by plastics has been the subject of much study and experimentation. Most plastics are affected one way or another by contact with water—either the physical characteristics undergo some change or the dielectric qualities are affected in some manner. It need not necessarily be contact with water itself which produces the change, but merely exposure to varying humidities representative of operating conditions. Comparisons of the effects of moisture upon various plastics are not only of fundamental interest but also of practical significance.

A series of tests upon the absorption of water by plastics, covering a 2-yr. period of time, has been reported,<sup>1</sup> in which weight changes and linear dimensional changes were recorded. These tests laid the background for the A.S.T.M. Specification D570-42 on water absorption. Further research showed that the immersion of plastics in boiling water brought about measurable changes in a shorter time than is possible with room temperature tests.<sup>2</sup>

The tests reported in this paper are designed to make available a rapid and accurate method of evaluating the water absorption of plastics. Results are based upon dimensional changes in the plastic, since dimensional variations hold more practical significance in the case of plastics than do weight changes. Instead of relying upon linear dimensional changes, which are small and difficult to observe in a few hours, the effect of moisture is evaluated by the bending of a simple cantilever beam of plastic under extremes of moisture gradient. Various types of beams were studied, including those of two points of support. However, the simple canti-

lever type was finally chosen because of its greater end deflection for a given absorption.

## Method of test

The method used in testing is relatively simple and has the advantage over other methods in that readings are taken during the time the plastic is in contact with water. One source of serious error in the methods which rely upon normal weight change is the rapid loss of moisture from samples studied after removal from the bath.

Samples are cut to lengths of say 5 or 6 in. and thicknesses of about  $\frac{1}{8}$  in., and coated along one side. The cut edges are then covered with a thin moisture-impervious film of metal, 1 mil thick, which is held in place by a thin adhesive coating not chemically reactive with the plastic. These samples are preferably conditioned at the desired atmosphere before being protected with foil. The presence of the foil on one side makes an extreme moisture gradient possible, inasmuch as the entry of moisture is limited to one side. A small piece of wire is wrapped about the end and allowed to protrude about one inch so that when it is immersed in water, electrical contact may be made on the protruding wire.

Immediately upon the immersion of the plastic in the water, a depth gage records the position of the specimen. For this purpose manually operated gages exerting negligible contact pressure are preferred. A sensitive grid control circuit may be used to measure the contact electrically. It is important to take a quick reading for most materials because deflection starts the instant the unprotected fibers make contact with water. The fibers begin to swell and the specimen, supported as a cantilever beam, begins to bend. Changes are rapid and several readings can usually be obtained during the first hour. Even such materials as polystyrene exhibit measurable dimensional changes during the first 3 hours, while materials like cellulose acetate deflect almost visibly during contact with water. Differences in results between the plastics are quite marked. This fact will be noted in the data that is presented.

Unlike the mechanical loading of a simple cantilever beam, fiber stress does not vary in accordance with the distance from the support, and it may be assumed that elongation phenomena are substantially uniform at the same distances from the neutral axes. Of course, the total movement at the end of the beam depends upon the length as well as the thickness of the beam, though these variables are rationalized into a constant slope when the log of deflection is plotted against the log of time.

Creep phenomena due to the weight of specimen and foil are negligible, particularly when the buoyant effect of water is considered. Sturdily mounted supports for the depth gage and specimen will reduce instrument errors. However, the most serious errors are encountered at large deflections when the angle of slope at the end of beam becomes appreciable. Corrections were not made for (Please turn to page 188)

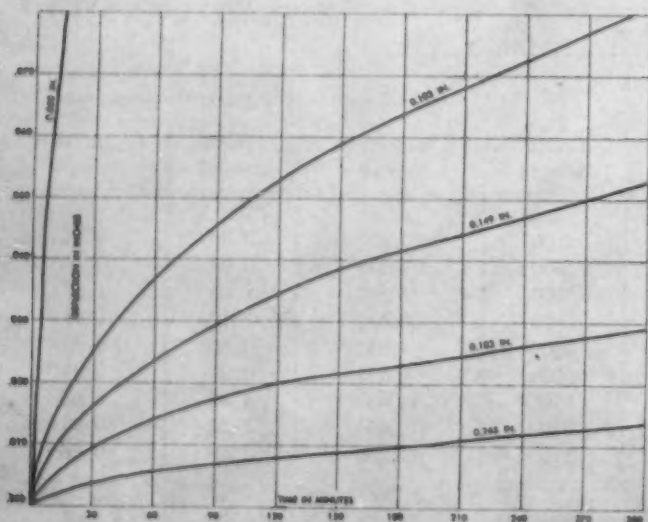
\* Plastics Industries Technical Institute.

\*\* Montreal Technical School.

<sup>1</sup> "Sorption of Water by Plastics," by G. M. Kline, A. R. Martin and W. A. Crouse, MODERN PLASTICS 18, 119-23, 152, 154 (Oct. 1940).

<sup>2</sup> "Dimensional Changes of Plastics in Boiling Water," by Reginald L. Wakeman, MODERN PLASTICS 18, 65-8, 86 (July 1941).

1—The curves on this graph show deflection for polymethyl methacrylate as a function of time and thickness





# **LIGHTNING STOPPER**

**L**IGHTNING ARRESTERS with housings molded of transparent Tenite are used in the communications systems of the Signal Corps and other branches of the armed forces. During thunderstorms, the glow of a small neon tube, visible through the transparent plastic, indicates a satisfactory connection between antenna and ground terminal. Installations are thus protected from serious damage.

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## **TENITE**

**AN EASTMAN PLASTIC**

*Lightning arrester housings molded by Sterling Plastics Company, for L. S. Bruch Manufacturing Corporation.*

# Life ON THE P



(Above) **BATHROOM LIGHTING FIXTURES**, molded of pearl white BEETLE\* by Universal Plastics Corporation for the Lightolier Co. are shown as they come off the assembly line. They are light in weight, durable, shatter resistant, and easy to clean.



(Above) **BEETLE MOLDING MATERIAL** for the lamp shade is preheated to approximately the molding temperature to produce a finished piece superior in appearance and extremely resistant to service conditions.



(Above) **FINISHED PIECES** can be turned out of the mold rapidly because of the short molding cycle possible in making this BEETLE lamp shade. This means fast, economical production.



(Above) **HIGHER PRESSURES**, without preheating, are used in molding the lamp base, smaller and heavier than the shade, making possible an even faster complete molding process.

(Right) **BASE AND SHADE** then go to the assembly line where lens and socket are inserted and the two molded pieces slipped together and fastened with a metal spring clip.

● **PROPERTIES INHERENT IN BEETLE** are responsible for its growing use as a material for lighting applications. Its unusual light diffusing qualities can be controlled as to color and degree by the wide range of translucent shades available. It is light in weight, shatter resistant, and may be molded into many intricate shapes for fast economical production.

These bathroom lighting fixtures molded by the Universal Plastics Corporation for large volume sale are excellent examples of BEETLE's utility not only for home lighting, but for office, factory, schools, and public lighting.

The supply of BEETLE for the manufacture of civilian items is being constantly increased. Your molder will work with you in planning the adaption of BEETLE to new designs and products. BEETLE's wide range of colors makes it particularly applicable, also, for packaging, flashlight, razor and clock cases, radio housings, and other similar uses.



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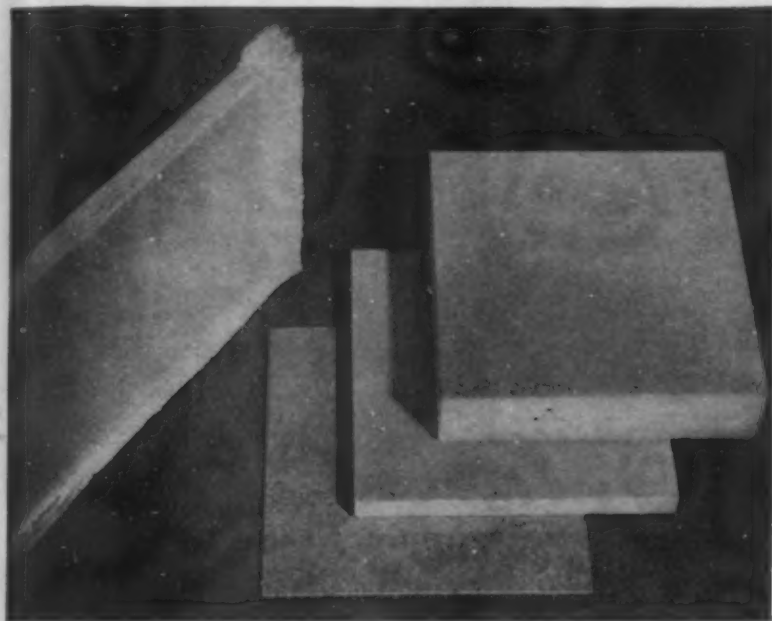
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# E PLASTICS NEWSFRONT



(Above) **MELMAC® LAMINATES**, fabricated by The Formica Insulation Company, are used as electrical insulation, parts for mechanical applications, and decorative sheets for furniture and building purposes. MELMAC assembly with three different base materials is shown here. Sample at left is  $\frac{1}{2}$ " glass fabric panel showing flash indicating compression due to pressing at 1100 lbs. per sq. in. Samples at right are  $\frac{1}{16}$ " asbestos paper base,  $\frac{1}{2}$ " glass fabric, and  $1\frac{1}{2}$ " muslin base.



(Above) **FLAME RESISTANCE TEST**, made by The Formica Insulation Company, demonstrates the relative flame resistance of phenolic (left) and melamine (right) laminates. As shown here, when the flame was lowered, the phenolic was burning while the melamine failed to support combustion. Both samples are cellulose base laminates. Non-inflammability and high heat resistance are characteristic of MELMAC, Cyanamid's melamine laminating resin, as well as all MELMAC molding compounds.



(Above) **NEW STANDARDIZED PALLETS** of clothing containers, loaded in units 4' by 4' by this "fork truck," simplify the U. S. Naval Clothing Depot's job of keeping more than a million garments a day moving to the Naval Forces. Cyanamid's URAC® resin adhesives are used to weatherproof such paperboard containers for export to all parts of the world.

(Right) **DESIGNERS, ENGINEERS**, and others interested in the fabrication and use of plastics immediately or postwar now have available a valuable handbook of information on Cyanamid plastics. The new manual, "MELMAC MOLDING COMPOUNDS," contains a complete summary of technical data on Cyanamid molding materials currently available. A copy will be sent on request.



\*Reg. U. S. Pat. Off.

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# TECHNICAL BRIEFS

Abstracts of articles on plastics in the world's scientific and engineering literature relating to properties and testing methods, or indicating significant trends and developments.

## Engineering

**R-F HEATING FOR FABRICATING WOOD AIRCRAFT.** J. P. Taylor. *Electronics* 17, 108-13 (Mar. 1944). The advantages of radio-frequency heating for fabricating curved wooden parts for aircraft and furniture are discussed. Equipment for making wooden fuselage rings by radio-frequency heating is described.

**SKIN TROUBLES FROM TEXTILES.** W. Schweisheimer. *Textile Colorist* 66, 69-70 (Feb. 1944). The number of publications concerning dermatitis from textiles is steadily increasing. These cases usually arise from synthetic fibers or synthetic resin finishing materials. All such materials which come in contact with the skin should be tested before they are put on the market. Suggestions for such tests are given. Dermatitis resulting from vinyl resin wrist-watch bands, garters, suspenders and corsets is described.

## Chemistry

**CURING OF MELAMINE-FORMALDEHYDE CONDENSATION PRODUCTS.** R. Köhler. *Kolloid-Z.* 103, 138-44 (1943). Curing experiments were made at 100 and 130° C. The initial condensation products are slightly soluble in water and soluble in pyridine. As the condensation proceeds the solubility in pyridine decreases. The molecular weights of the starting resins were between 800 and 1000. After the pyridine solutions were heated for several hours, the molecular weight increased to more than 3000. Small amounts of formaldehyde were evolved in the heating experiments. The starting resins consisted of 4,5-methylolmelamine units connected by ether linkages; the number of ether linkages increases during curing. Resins containing 12 to 15 triazine units are soluble in pyridine.

**ACETYLATION OF ALKYL LACTATES.** M. L. Fein and C. H. Fisher. *Ind. Eng. Chem.* 36, 235-8 (Mar. 1944). Methyl acetoxypropionate, the acetyl derivative of methyl lactate, is an important intermediate because it yields methyl acrylate on pyrolysis. Simple and efficient methods are described for acetylating methyl lactate with acetic anhydride, ketene and acetyl chloride. Methyl lactate was acetylated continuously and in high yields with acetic anhydride and ketene. Large-scale labo-

ratory apparatus suitable for preparing methyl acetoxypropionate continuously at rates as high as 95 lb. per 24-hr. day is described.

## Properties

**STRUCTURE AND PHYSICAL PROPERTIES OF PLASTICS. I. THEORETICAL.** R. F. Tuckett. *Chem. & Ind.* 62, 430-2 (Nov. 13, 1943). A knowledge of the connection between the physical properties and the chemical structure of plastics is becoming increasingly necessary for practical reasons. In the past, the plastics industry has taken a limited number of available polymeric products and found, often empirically, the most suitable material for a particular purpose; this has often involved an unsatisfactory compromise. Much work is necessary before structure and behavior can be correlated. This correlation must be developed along 2 lines: 1) the relation between structure and various simple physical magnitudes which can be exactly defined; 2) the connection between these exact properties and the actual tests used industrially to characterize materials. A simplified account of the general principles involved in deformation is given.

**THE FAST AND SLOW EXTENSION OF SOME PLASTIC MATERIALS.** R. N. Haward. *Trans. Faraday Soc.* 39, 267-80 (Nov. 1943). The work taken up by any material under impact may be governed either by the rate at which deformation can take place or by the amount of possible deformation. The results of fast and slow extension experiments with cellulose acetate, cellulose nitrate and methyl methacrylate resin are examined, and it is found that in this way apparent contradictions can be resolved. Experiments were carried out on the extension and breaking of cellulose acetate film at different temperatures, and it is concluded that temperature changes during adiabatic extension will not be so large as to alter fundamentally the character of the deformation. The work absorption of different materials under changing conditions of testing varies both relatively and absolutely, and the validity of a generalized impact strength is questioned. A more precise formulation of shock conditions appears desirable.

**NEW ELECTRIC PHENOMENON IN SYNTHETICS.** C. Fischer and F. H. Müller. *Kolloid-Z.* 101, 43 (1942). The diffusion of water through a dielectric

material creates an electrical current within the material. This current is of the order  $10^{-4}$  amperes in high polymers; the magnitude depends on the time of diffusion until equilibrium is reached. The current increases rapidly from the beginning of diffusion to a maximum value, after which it decreases very slowly. The time required for the maximum current to develop is different for different polymers. For polystyrene, polyvinyl chloride and cellulose triacetate, the time is about the same. The maximum current and the permeability coefficient are interrelated. With a series of polyvinyl chlorides of various permeabilities, a relatively low permeability was associated with a relatively slow rise to a relatively low maximum current. The mechanism for this phenomenon is unknown. If the current is carried by the molecules of diffusing water, then the elemental charges of approximately  $10^{11}$  molecules of water are in motion. This corresponds in an approximate manner to the dissociation of water. Then the charge may depend on the different permeabilities of the high polymers for the different ions in the water.

## Testing

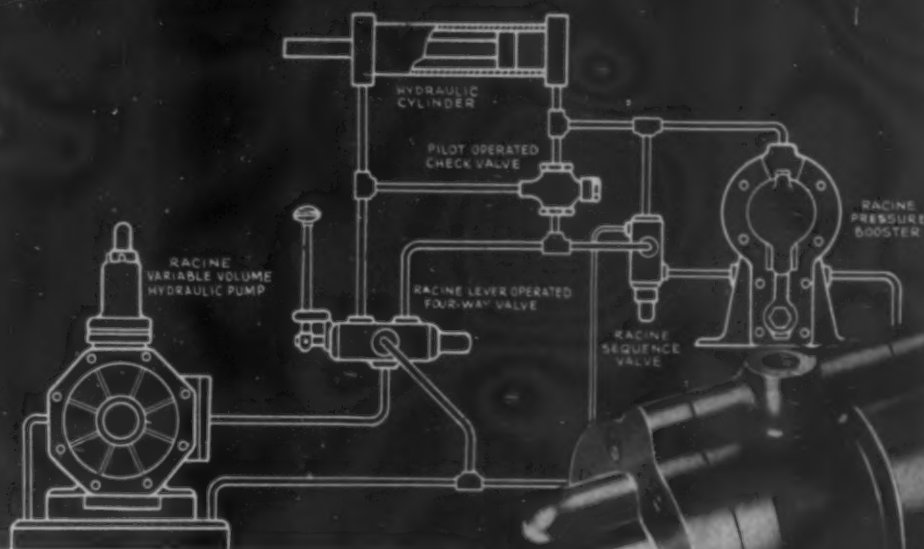
**DETERMINING PLASTICIZER CONTENT OF CELLULOSE ESTERS.** B. S. Biggs and R. H. Erickson. *Ind. Eng. Chem., Anal. Ed.* 16, 93-4 (Feb. 1944). Plasticizer content is determined by the vacuum distillation of the plasticizer from the sample. Dry samples of one gram or less are placed in weighing bottles on the floor of a special vacuum still heated with Dowtherm. The sample is quickly converted to a film by action of a solvent and heating is continued for 1.5 hours. The loss in weight is due to plasticizer plus a slight decomposition of the cellulose ester. The latter is determined on a blank but is usually small enough and uniform enough so that a fixed value may be assumed for it. Plasticizer content can be determined within about 0.3 percent.

**MOLECULAR WEIGHT DETERMINATIONS BY PRECIPITATION TITRATION.** B. Jirgensons. *J. prakt. Chem.* 161, 30-48 (Aug. 1942). The precipitation-titration method is an empirical one which depends on the linear relation between the precipitant necessary to produce turbidity and the logarithm of the molecular weight. The accuracy varies between 5 and 30 percent.

**METHOD FOR ESTIMATING THE SHEAR MODULUS OF ELASTICITY.** L. E. Welch. *Product Eng.* 15, 215-16 (Mar. 1944). Data are presented which show that the ratio of the shear modulus of elasticity to the tensile or compressive modulus of elasticity for various phenolic molding materials is approximately 0.385 and that Poisson's ratio for these materials is approximately 0.30, range 0.28 to 0.35.

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# PLASTICS DIGEST

This digest includes each month the more important articles of interest to those who make or use plastics. Mail request for periodicals directly to publishers.

## General

**LAMINATED PAPER PLASTICS.** P. W. Griffith. *Chemurgic Digest* 2, 153, 155-6 (Sept. 30, 1943). High-strength laminates are obtained by the use of bleached and unbleached kraft papers. The paper must meet the following specifications: 1) the weight per unit area must be uniform; 2) the thickness must be uniform and controlled; and 3) the pH must be controlled. The weight and thickness have a marked effect on the rate at which the paper absorbs the resin solution. The pH may affect the curing characteristics of the resin.

**LIGNIN INDUSTRIAL PLASTICS FROM FOREST PRODUCTS WASTE.** Modern Industry 6, 42-5 (Oct. 1943). The possibilities of lignin as a source of molding compositions, plastic fillers, extenders for phenolic resins and chemicals are discussed. Data on plastic materials of these types are given.

**THE INDUSTRY OF POLYMERS AND MACROMOLECULES.** F. J. Brislee. *Chem. & Ind.* 1944, 38-41 (Jan. 29, 1944). A general discussion of the relation of the plastics industry to the rubber and oil industries.

## Materials

**PROPERTIES AND USES OF CHLORINATED PARAFFINS.** W. E. Scheer. *Chemical Industries* 54, 203-5 (Feb. 1944). The properties and uses of the chlorinated paraffins are described. The 3 types of greatest commercial use are: 1) a nonvolatile liquid with about 43 percent combined chlorine, 2) a soft solid resin with about 60 percent combined chlorine and 3) a hard brittle resin containing about 70 percent combined chlorine. These products are made by chlorinating a paraffin wax with a melting point of 125 to 130° F. The major uses are for fabric impregnation, as plasticizers, for fireproofing, in corrosion-resistant compositions, in special paints and as an oil additive.

**NYLON.** M. Shor. *J. Chem. Education* 21, 88-92 (Feb. 1944). A concise description of the research development, method of production and properties of nylon is presented.

**PROPERTIES OF POLYETHYLENE SUGGEST PEACETIME APPLICATIONS.** *Product Eng.* 15, 202-3 (Mar. 1944). The properties and possible future applications of polyethylene are discussed. Possible future applica-

tions include containers, collapsible tubes, gaskets, battery parts, flexible tubing, rigid piping, coatings, wire and cable insulation, adhesives, films and sheets.

**METHYL CELLULOSE AND CELLULOSE ADHESIVES.** *Gelatine, Leim, Klebstoffe* 10, 106-12 (Sept.-Oct. 1942). The use of methyl cellulose as an adhesive is discussed. It is recommended as a wall-paper adhesive. Procedures are given for making methyl cellulose by the process of treating pulp wood with dimethyl sulfate.

## Applications

**COMPARISON OF METHODS FOR IMPROVING WOOD.** L. Klein, H. Grinsfelder and S. D. Bailey. *Ind. Eng. Chem.* 36, 252-6 (Mar. 1944). Three methods for improving the physical properties of wood are compared. In the first method the wood is impregnated with phenol-formaldehyde resin and then compressed. In the second method, veneers are bonded together under heat and pressure with resin film. In the third method the veneers are coated with liquid resin and then bonded with heat and pressure. The strength properties resulting from each method are different. The properties which were compared include dimensional stability to water and heat, tensile strength, impact strength, ease of compression, shear strength, modulus of elasticity in bending, modulus of rupture, ease of manufacture, surface appearance and cost. The fields of application for material of this type include airplane and ship propellers, bearing plates, jigs, rollers, gears, gun stocks, sporting goods, table tops, heavy-duty flooring, etc.

**PLASTIC FIXTURES MODERNIZE AIRCRAFT CABIN LIGHTING.** L. Schepmoes. *Aero Digest* 44, 96, 199 (Mar. 1, 1944). Methyl-methacrylate plastic is recommended for use in making aircraft cabin lighting shades. The good fatigue resistance, toughness, freedom from shrinkage, warpage and discoloration, ease of forming, lightness and high degree of light transmission of this material make it a very satisfactory material for this purpose.

**SOYBEAN ADHESIVES.** I. F. Laucks. *Chemurgic Digest* 2, 173, 175-6, 185-8 (Oct. 30, Nov. 15, 1943). Two of the largest uses of soybean glue are in the manufacture of waterproof plywood and as a glossy paper coating. The development and use of a hotpress soybean

glue for the manufacture of plywood is described. A large part of the washable wall paper on the market is now made with a soybean coating.

**SENSITIZED POLYVINYL ALCOHOL.** J. Albrecht. *Kolloid-Z.* 103, No. 2, 166-70 (1943). Polyvinyl alcohol sensitized with the condensation products of aldehydes and diazo compounds can be used in emulsion coatings in place of dichromates.

## Coatings

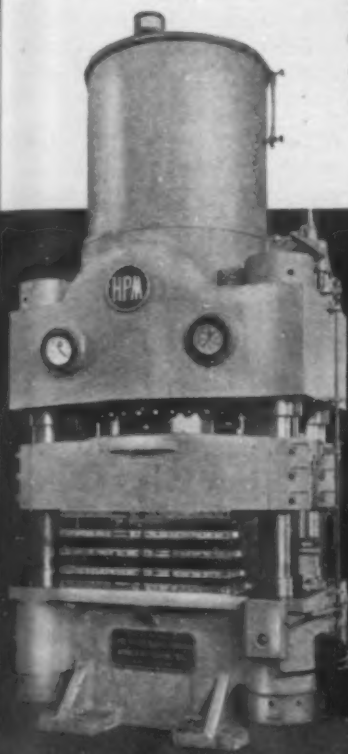
**DETERMINATION OF THE RESISTANCE OF PAINT FILMS TO ACIDS, ALKALIS AND SALTS.** J. Rosendorf. *Farben-Ztg.* 47, 163-4 (1942). In the ring-bowl method an iron plate having a circular hollowed portion of a standard diameter and concavity is sprayed with a film of lacquer and dried. The hollow portion is circumscribed with an annulus which is filled with petrolatum. The film is covered with the corroding solution. A glass vessel which has a diameter of such size that it fits into the annulus is forced into the ring of petrolatum to form an airtight cover. The apparatus is suitable for making tests of any duration and at elevated temperatures. The advantages are: 1) the film is exposed only to the corroding solution and not to an air-solution interface, 2) the concentration of the solution will not vary and 3) observations can be made at any time during the progress of the test.

**PLASTICIZERS FOR CELLULOSE NITRATE LACQUERS.** XXIX. **ESTERS OF *p*-TOLUENE-SULFONIC ACID.** A. Kraus. *Farbe u. Lacke* 1943, Nos. 5-6, 27-8. The solvent power of methyl, ethyl, isoamyl, lauryl, cetyl, oleyl, phenyl, naphthyl, cyclohexyl and dimethylcyclohexyl esters of *p*-toluene-sulfonic acid for lacquer-grade cellulose nitrate was studied. The lower aliphatic esters are good solvents; with increasing molecular weight of the aliphatic chain, the solvent power decreases, becoming practically zero for the cetyl and oleyl esters. The phenolic esters dissolve cellulose nitrate in the cold only when ethyl alcohol or butyl alcohol is present. All the esters dissolve cellulose nitrate, give clear solutions and produce clear-drying lacquers. Crystals of the phenyl and naphthyl esters separate from the lacquer films. Data are given on compatibility, strength, flexibility and light and water resistance of the films.

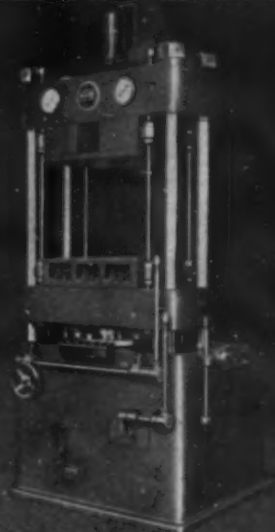
**DURABILITY OF LUSTERLESS ENAMELS.** S. E. Beck. *Ind. Eng. Chem.* 36, 157-8 (Feb. 1944). The results of outside exposure tests on steel panels coated with 79 lusterless enamels are reported. The influence of the binder on the durability is discussed.

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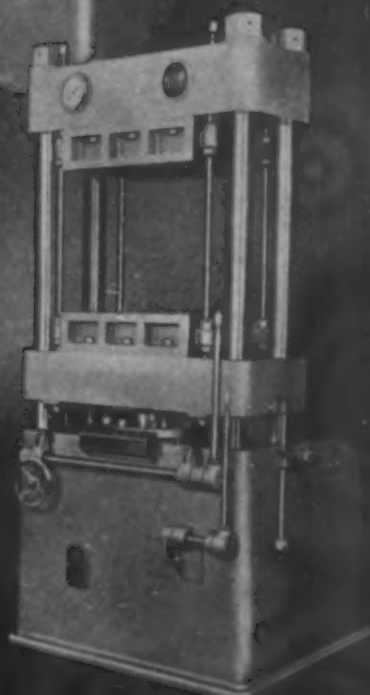
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# U.S. Plastics Patents

Copies of these patents are available from the U. S. Patent Office, Washington, D. C., at 10 cents each

**COFFEE PLASTICS.** H. S. Polin and A. I. Nerken (to H. S. Polin). U. S. 2,340,426, February 1. A molding material is prepared from coffee beans by removing the oil from the green bean, fractionating the oil, reintroducing the oleic and linoleic fractions of the extracted oil into the extracted coffee bean, and subjecting to heat, pressure, mineral acid and steam for removal of furfural, recovering the furfural, and adding a portion to the treated bean residue.

**MATERIAL DISPENSER.** E. D. Skinner (to Kenmar Manufacturing Co.). U. S. 2,340,433, February 1. A dispenser of plastic material comprising a piston and a cylinder body composed of a synthetic thermosetting resin.

**ADHESIVE.** C. L. Child, R. B. Fisher, F. Clarke and B. J. Habgood (to Imperial Chemical Industries, Ltd.). U. S. 2,340,452, February 1. A material comprising a base, an adherent intermediate film of polymerized ethylene and one part of a cyclo rubber, and a surface film of polymerized ethylene.

**GLAZING UNIT.** F. W. Hall (to Pittsburgh Plate Glass Co.). U. S. 2,340,469, February 1. A multiple glazed unit comprising adjacent glass plates disposed in parallel, a spacer of thermoplastic resinous material and metal foil traversing the space from plate to plate around the marginal portions, thus forming a vapor barrier.

**LIGHT POLARIZER.** L. A. Keim (to Pittsburgh Plate Glass Co.). U. S. 2,340,476, February 1. A laminated assembly comprising a pair of glass plates bonded by an intermediate layer of a sheet polarizing member containing an intermediate layer of polyvinyl acetal resin having optically oriented polarizing crystals dispersed therein and layers of partial polyvinyl acetal resin containing plasticizer which are directly bonded to glass plates.

**POLYVINYL ACETAL RESIN.** W. H. Lycan (to Pittsburgh Plate Glass Co.). U. S. 2,340,482, February 1. A blend of polyvinyl acetal and a mixed ester of a glycol and 2 saturated aliphatic monocarboxylic acids.

**ABRASIVE.** W. E. Beatty. U. S. 2,340,504, February 1. Abrasive particles are interlocked by a solution of ethyl cellulose.

**POLYAMIDES.** O. E. Dwyer (to E. I. du Pont de Nemours and Co., Inc.). U. S. 2,340,652, February 1. A transparent article is prepared from a metal salt-alcohol solution of a synthetic linear polyamide by forming an article, evaporating the alcohol and washing the salt from the article with water.

**VINYLDENE CHLORIDE.** A. W. Hanson (to Dow Chemical Co.). U. S. 2,340,834, February 1. Finely divided particles of polymeric vinylidene chloride are formed into shaped bodies by preheating, causing the mass to move over a cooled surface with slight pressure and finally fusing by contacting with a heated surface.

**RESIN.** F. P. Otto and O. M. Reiff (to Socony Vacuum Oil Co., Inc.). U. S. 2,340,838, February 1. A hard resin is formed by reacting a phenol with a chlorinated petroleum wax in the presence of a Friedel-Crafts catalyst, decolorizing with zinc metal and water, and catalytically hydrogenating.

**POLYVINYL ALCOHOL.** C. Dangelmajer (to Resistoflex Corp.). U. S. 2,340,866, February 8. A flexible homogeneous plasticized polyvinyl alcohol capable of being formed with heat

and pressure without loss of homogeneity, comprising polyvinyl alcohol, water, glycerol and formamide.

**WINDING ELEMENT.** F. J. Sigmund and W. S. Hlavin (to Lake Erie Chemical Co.). U. S. 2,340,905, February 8. A castable resin is used to support windings in slots on a magnetized winding element.

**PROLAMINE PLASTIC.** H. M. Weber (to American Maize-Products Co.). U. S. 2,340,913, February 8. Anhydrous zein solution is prepared by homogenizing dry zein in an organic solvent and heating to drive off water.

**CONDUIT.** S. D. Bradley (to Detroit Macoid Corp.). U. S. 2,340,926, February 8. A conduit for receiving electrical conductors provided with internal partitions is molded from plastic material.

**WATERPROOF TAPE.** F. N. Manley and E. P. Wenzelberger (to Johnson and Johnson). U. S. 2,340,971, February 8. A waterproof fabric is used as a backing for adhesive comprising cellulose acetate and methyl phthalyl ethyl glycolate.

**RESINS.** E. E. Novotny (to Durite Plastics, Inc.). U. S. 2,341,115, February 8. An oil-insoluble resin is prepared by heating a mixture of cashew nut shell liquid and a thermoplastic phenolic resin; this product is then cured with a hardening agent.

**ARTIFICIAL TEETH.** S. Myerson. U. S. 2,341,153-4-5-6, February 8. Artificial dental impressions, temporary supports and holders are prepared from synthetic resins.

**POLYSTYRENE.** E. C. Britton, H. B. Marshall and W. J. LeFevre (to Dow Chemical Co.). U. S. 2,341,175, February 8. A friable, solid polymer derived from styrene which is insoluble and non-swelling in benzene.

**POLYSTYRENE.** L. A. Matheson and R. F. Boyer (to Dow Chemical Co.). U. S. 2,341,186, February 8. A plastic composition comprising polystyrene and a small amount of morpholine palmitate.

**PELLETING MACHINE.** G. A. Frenkel (to Shell Development Co.). U. S. 2,341,213, February 8. A machine for preparing pellets of plastic material.

**INSULATING FABRIC.** H. N. Jones (to Owens-Corning Fiberglas Corp.). U. S. 2,341,219, February 8. An electrical insulating fabric comprising mineral fibers bonded with an organic resin.

**PRIMING COMPOSITION.** W. Brün and G. M. Calhoun (to Remington Arms Co., Inc.). U. S. 2,341,262, February 8. A rim-fire priming mixture comprising lead nitrate-hypo-phosphite and a binder of polyvinyl alcohol.

**RESIN.** G. F. D'Alelio (to General Electric Co.). U. S. 2,341,266, February 8. A resin is prepared by reacting a urea, an aliphatic aldehyde, an aldehyde reactable salt and an amino compound such as amino carboxylic acid amides, amino sulfonamides and amino nitriles.

**RESIN.** G. F. D'Alelio and J. W. Underwood (to General Electric Co.). U. S. 2,341,267, February 8. An acid-curing thermosetting resin carrying a curing agent comprising a tri-aziny halogeno-cyanoalkyl sulfide.

(Please to next page)

# Mold Your Ideas . . . in PLASTICS

## Another Plastics Success Story

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**POLYVINYL KETALS.** C. L. Egge, G. L. Dorrough and W. E. Hanford (to E. I. du Pont de Nemours and Co., Inc.). U. S. 2,341,306, February 8. Polyvinyl ketal is prepared by reacting polyvinyl alcohol with a monomeric ketal in an anhydrous solvent vehicle in the presence of a condensation catalyst.

**CAMERA SPOOL.** F. G. Purinton (to Patent Button Co.). U. S. 2,341,333, February 8. A film spool including a plastic spindle.

**VINYL COMPOUNDS.** H. J. Richter (to E. I. du Pont de Nemours and Co., Inc.). U. S. 2,341,334, February 8. An interpolymer of methylene dimethacrylate and a polymerizable unsaturated organic compound such as a vinyl or vinylidene compound.

**ADHESIVE.** C. O. Strother and C. W. Patton (to Carbide and Carbon Chemicals Corp.). U. S. 2,341,308, February 8. An adhesive is prepared by forming a solution of polyvinyl acetate in a solvent containing no free hydroxyl groups, reacting with an aliphatic alcohol in the presence of hydrogen chloride, neutralizing the acid with an alkylene oxide and obtaining a water-insoluble product in which the ester groups in the polyvinyl acetate have been partially replaced by alcoholic hydroxyl groups.

**POLYAMIDE FIBERS.** W. E. Catlin (to E. I. du Pont de Nemours and Co., Inc.). U. S. 2,341,423, February 8. An oriented linear polyamide filament is treated with a solution of a phenol in a nonsolvent for the filament, after which the phenol is removed by a similar solvent.

**CELLULOSE ETHERS.** C. J. Malm and C. L. Crane (to Eastman Kodak Co.). U. S. 2,341,455, February 8. An ethyl cellulose is stabilized by adding aqueous methyl ethyl ketone to give a smooth plastic mass, and adding acetic acid to give a pH of seven.

**CELLULOSE ESTERS.** L. W. A. Meyer (to Eastman Kodak Co.). U. S. 2,341,464, February 8. A fatty acid ester of cellulose contains ethylene glycol dicaprate as a plasticizer.

**BADGE.** M. Nedell. U. S. 2,341,467, February 8. An identification badge comprising a plastic carrying body and a plastic crystal.

**VINYL RESIN.** R. C. Houtz (to E. I. du Pont de Nemours and Co., Inc.). U. S. 2,341,553, February 15. A vinyl resin having cyanoethyl ether groups.

**DENTURE.** I. J. Dresch (to Dresch Laboratories Co.). U. S. 2,341,604, February 15. A denture comprising a base plate of polystyrene having portions of a thermoplastic resin with affinity for the polystyrene in which the artificial teeth may be set.

**HIGH POLYMERS.** M. Hagedorn and E. Schmitz-Hillebrecht (to Alien Property Custodian). U. S. 2,341,611, February 15. Superpolymers are prepared by melting an aromatic polyamino carboxylic acid with an aliphatic amino carboxylic acid.

**MOLD.** S. M. Hull (to Western Electric Co., Inc.). U. S. 2,341,617, February 15. An electrostatic molding device consisting of mold sections of electrical insulating material forming a cavity, a pair of parallel plates of electrical conducting material, and means for applying an alternating electrical potential to said plates.

**SHEET MATERIAL.** K. Raschig (to Alien Property Custodian). U. S. 2,341,651, February 15. An apparatus for producing sheets of plastic material, comprising a supporting roller and a counter roller, and means for slitting the sheet.

**EYEPiece.** W. Walker (to Celanese Corp. of America). U. S. 2,341,673, February 15. An eyepiece comprising 2 transparent sheets, one of glass and the other of an organic thermoplastic, united by a flat annulus of the thermoplastic resin.

**POLYAMIDES.** W. E. Catlin (to E. I. du Pont de Nemours and Co., Inc.). U. S. 2,341,750, February 15. Polyamides are pigmented by mixing the pigment with the starting materials and polymerizing the latter.

**FILAMENT.** A. F. Smith (to E. I. du Pont de Nemours and Co., Inc.). U. S. 2,341,823, February 15. An artificial bristle comprising a mixture of a synthetic linear polyamide and a phenol-formaldehyde resin.

**FILM SUBLAYER.** E. B. Middleton, D. M. McQueen and J. R. Hill (to E. I. du Pont de Nemours and Co., Inc.). U. S. 2,341,877, February 15. A film element comprising a base of fusible water-insoluble synthetic linear polymer and having superposed thereon at least one layer comprising an organic colloid and a phenol.

**PLAYING CARD.** F. J. Sowa (to Kem Plastic Playing Cards, Inc.). U. S. 2,341,884-5, February 15. Plastic playing cards are prepared by applying to a plastic base sheet an invisible deposit comprising particles of a finely divided solid compound of a metal which forms coordination complexes, and applying over said particles a coating of moistureproof organic film-forming composition.

**POLYMERS.** A. L. Rummelsburg (to Hercules Powder Co., Inc.). U. S. 2,341,948, February 15. An acyclic terpene having 3 double bonds per molecule is polymerized by contacting in liquid phase with a porous silicate of a metal of Group II or III.

**SCREEN.** E. R. Dillehay (to Richardson Co.). U. S. 2,341,982, February 15. A projection screen comprising a thin, laminated panel-like, resinous body formed of bibulous laminae bearing a clear synthetic resin.

**WATERPROOF THREAD.** S. W. Alderfer (one half to E. D. Andrews). U. S. 2,342,098, February 22. An elastic waterproof thread comprising a central core of polyvinyl alcohol around which is wound a continuing jacket.

**VINYL POLYMERS.** W. H. Wood (to Harris-Seybold-Potter Co.). U. S. 2,342,175, February 22. Polyvinyl alcohol, its ethers and esters, are halogenated in aqueous medium, the supply of halogen being controlled to an amount yielding a water-soluble product.

**VINYL COPOLYMERS.** L. Orthner, H. Sönke and U. Lampert (to General Aniline and Film Corp.). U. S. 2,342,295, February 22. Interpolymers of vinyl compounds with cyclic amides of olefinic dicarboxylic acids, and N-alkyl and N-cycloalkyl substitution products thereof.

**POLYAMIDE.** H. J. Richter (to E. I. du Pont de Nemours and Co., Inc.). U. S. 2,342,370, February 22. A synthetic linear polyamide plasticized with a mixture of a solvent plasticizer and a nonsolvent plasticizer comprising an esterified ester of a carboxylic acid.

**COATING.** W. E. Catlin (to E. I. du Pont de Nemours and Co., Inc.). U. S. 2,342,387, February 22. A coating composition is prepared by adding a solution of a synthetic linear polyamide to a large volume of a nonsolvent, followed by dispersing in a nonsolvent by mechanical agitation.

**CELLULOSE ESTERS.** G. D. Hiatt and C. L. Crane (to Eastman Kodak Co.). U. S. 2,342,399, February 22. Cellulose esters are prepared by esterifying the cellulose with a reaction mixture consisting of a fatty acid, an impelling anhydride and an acylation catalyst, and subsequently treating under anhydrous conditions with an organic liquid such as acetic acid or acetone in an amount sufficient to extract a portion of the uncombined fatty acid.

**ETHYLENE POLYMER.** H. Hopf, S. Goebel and C. W. Rautenstrauch (to General Aniline and Film Corp.). U. S. 2,342,400, February 22. Solid polymerization products are prepared by polymerizing ethylene in an aqueous emulsion in the presence of an oxidizing agent under superatmospheric pressures.



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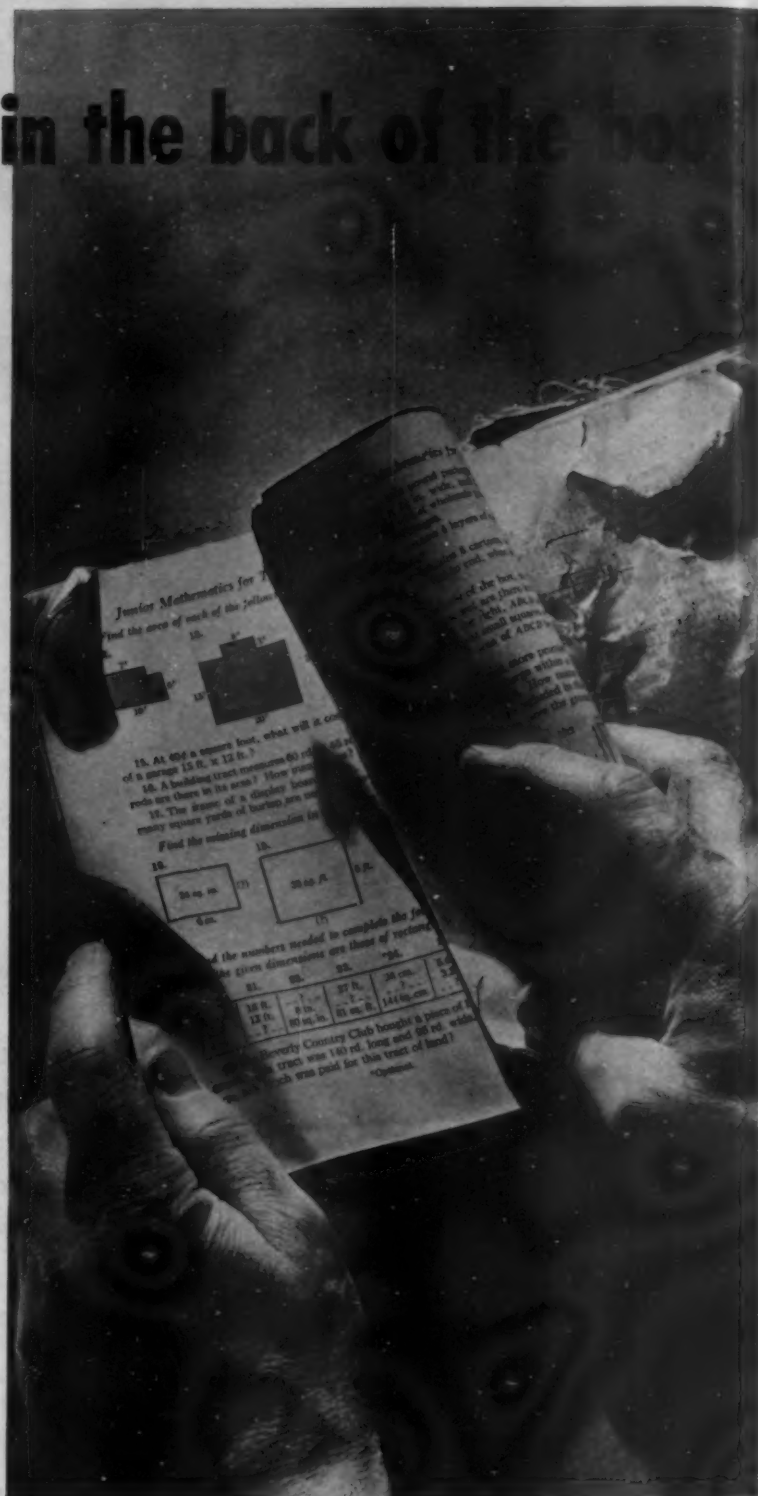
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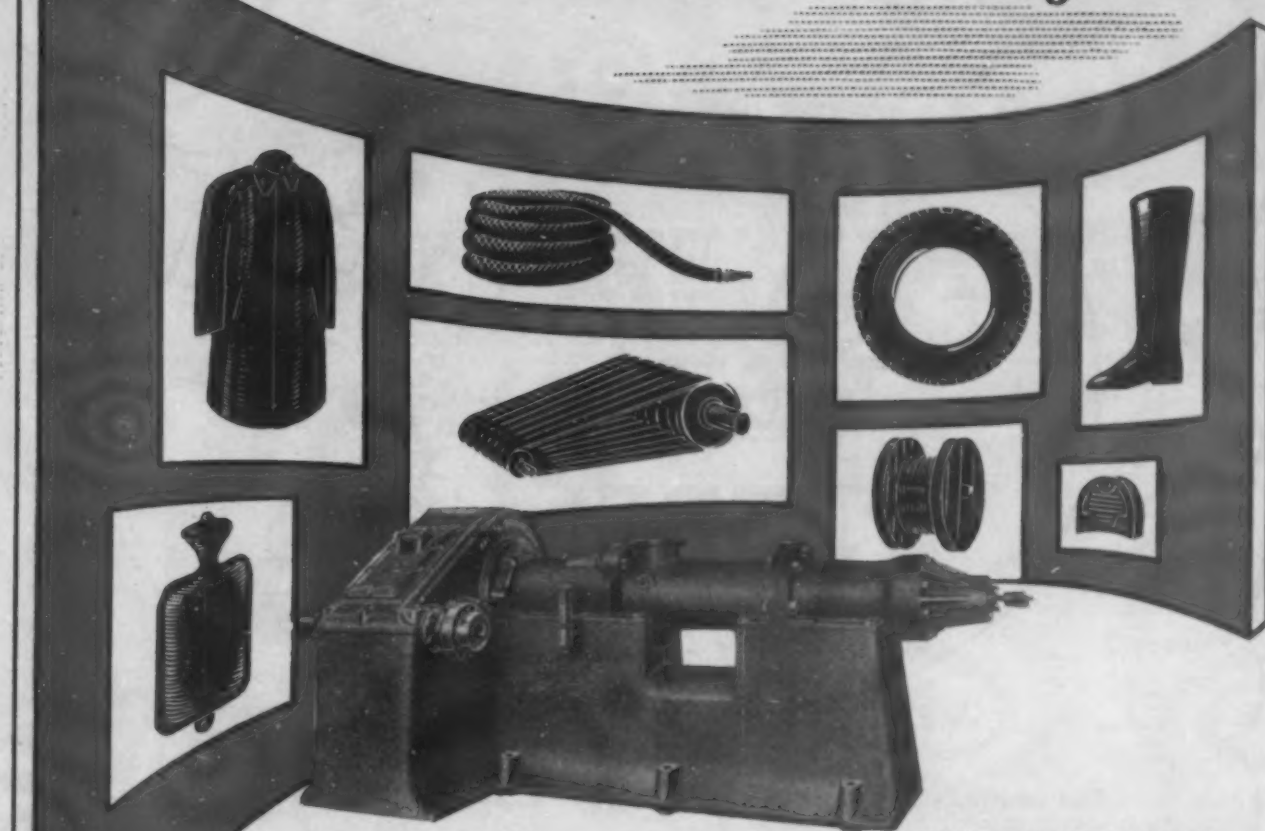
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A Centro-Matic System consists of a number of Centro-Matic Injectors—one for each bearing—and a power operated or a hand operated Centro-Matic Lubricant Pump. A power operated system can be either time clock control

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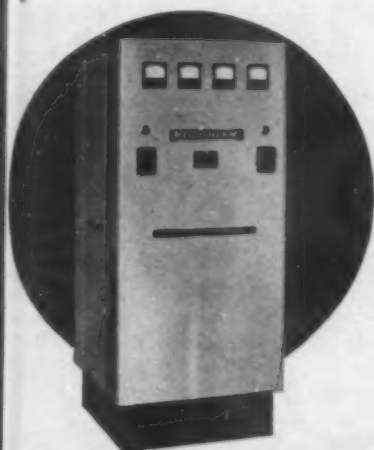
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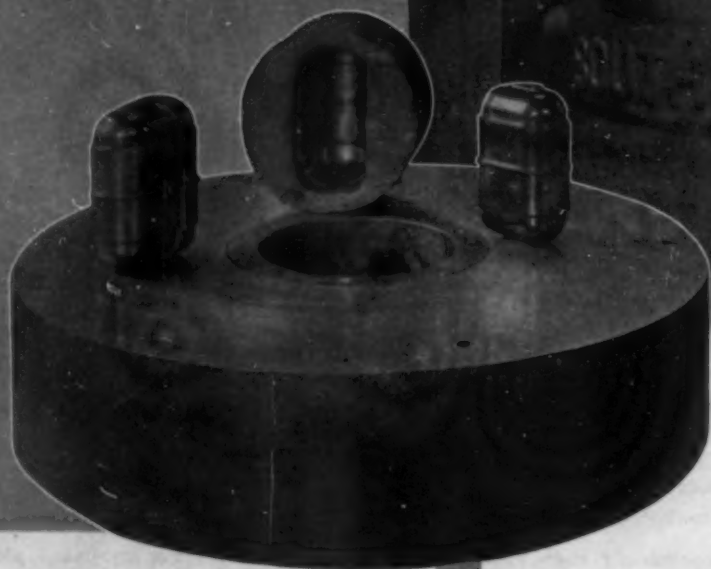


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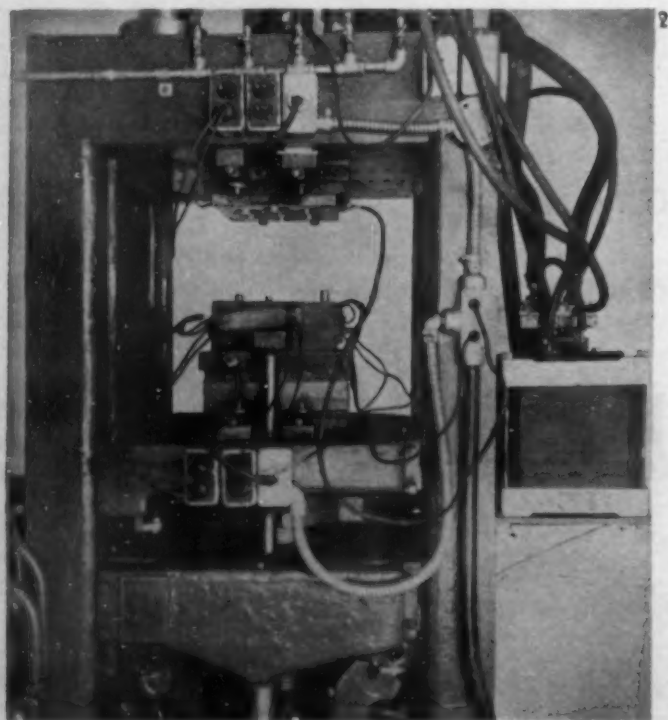
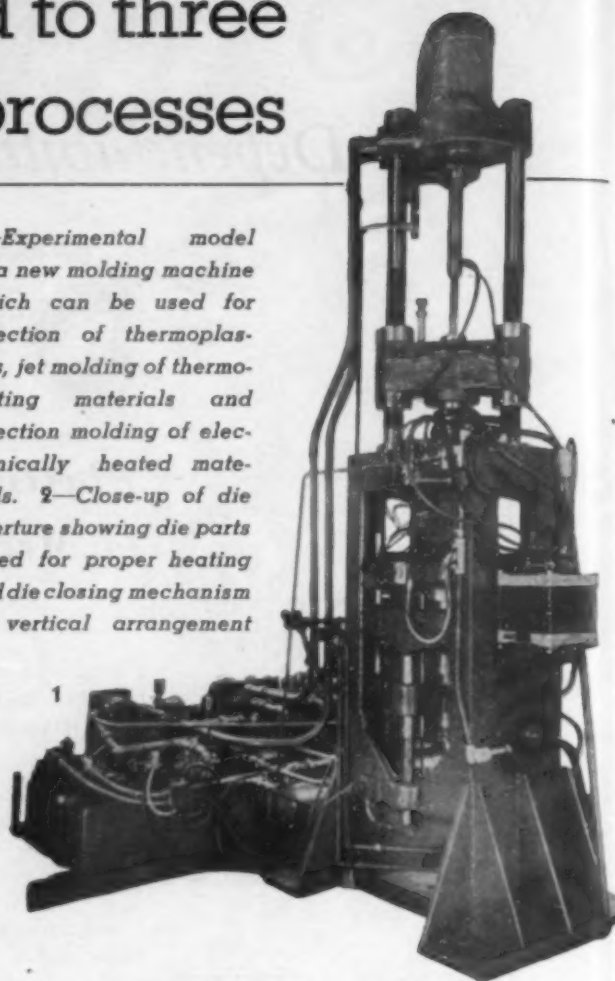
# New machine adapted to three separate molding processes

A SIGNIFICANT development in the history of plastic molding machinery is seen in a new molding press designed by the Lester Engineering Co. for Lester-Phoenix, Inc., of Cleveland, Ohio. The new model 3V-12 high-pressure hydraulic-injection press accomplishes 3 separate and distinct molding processes: 1) injection molding of thermoplastic materials, 2) jet molding of thermosetting materials, and 3) injection molding of electronically heated, preformed materials. All 3 processes may be carried out with little loss of time in converting from one to the other, and ordinary compression molding can be done if desired. Operation of the press can be automatic, semi-automatic or manual.

The press is constructed in a vertical design for a number of reasons. Basically, its frame and die-actuating mechanisms are those of the Lester 3S-27-12, a 12-oz. horizontal injection machine. Since the unit's normal injection capacity is a 12-oz. casting, the design might be said to be a vertical adaptation of the horizontal press with which most molders are familiar. A vertical press with platens in a horizontal position is better adapted to molding parts with inserts, since the inserts are less likely to jar loose when the mold closes. In jet molding, the vertical construction makes it possible to drop the material into the injection cylinder by gravity, thus feeding it more completely and uniformly. Since the plunger works vertically in the new vertical machine, much wear and tear on the injection cylinder is prevented.

The machine shown in Figs. 1 and 2 is an experimental model with hydraulic equipment and a 30-hp. electric motor mounted on a separate base. Future models may utilize the same design or the hydraulics may be on an integral base with the press, with the motor and pumps on one side and the valves and controls on the opposite side of the press, depending upon the requirements of the user. Vickers hydraulic equipment is used throughout and includes a special flow-control valve which controls the speed of the plunger at any point in its descent,

1—Experimental model of a new molding machine which can be used for injection of thermoplastics, jet molding of thermosetting materials and injection molding of electronically heated materials. 2—Close-up of die aperture showing die parts wired for proper heating and die closing mechanism in vertical arrangement



from a predetermined high velocity to zero. This control is particularly useful on long injection cycles. Volume and pressure on the injection system can be controlled independently.

In discussing the functions of the new press, little need be said about the injection molding of thermoplastic materials. This process is carried out in the same manner as in the standard machines, with a vertical injection cylinder using a hollow injection plunger. However, when using this design in a vertical press, the usual right-angle bend for delivery of the plastic material into the vertical die is unnecessary.

The choice between jet and injection molding of thermosetting materials is dictated primarily by the size and weight of the casting involved. Generally speaking, the jet process has been used chiefly in the production of castings up to 12 oz., while the injection process has been more extensively used for larger castings. However, any such limits are arbitrary and by no means final. These facts show the necessity for and utility of a molding press which will combine both types of thermosetting molding.

In usual compression molding, inserts may be displaced by the flow of material as the die closes, causing possible injury to the die. In both jet and injection molding, the die is closed first and the plasticized material injected about rigidly held inserts.

The Lester machine will handle any shape of preform but is designed particularly for the use of circular disks which, after pre-heating, are placed in a vertical injection cylinder and then driven by a hydraulic plunger through runners into the die cavities. A suggested method of handling preforms is to have them stacked in a vertical column. One of the preforms is then picked off the bottom and carried to a position between the electrostatic plates of a high-frequency generator.

The heat which is generated results from the effort of the molecules of the plastic preform to adjust themselves to alternating positive and negative high-frequency charges. Every par-

ticle of the disk will be of the same temperature at any given time, provided the material is uniform in composition and density. The amount of heat energy which is required is determined by the dielectric constant and the power factor of the material.

After the material has reached a temperature just short of its curing or setting temperature and has become plastic, the heated disk is mechanically transferred to the opening of the vertical injection cylinder. Several charges may then be placed in the cylinder preparatory to injection. The carrier device used for transferring the preform must be made of a material that is not affected by high-frequency current or by the heat of the preform. The hydraulically actuated plunger then injects the plasticized disk into the die. To accomplish the final curing or setting up of the castings in a fraction of the time required in conventional compression molding, heat is applied by resistance heaters within and about the die.

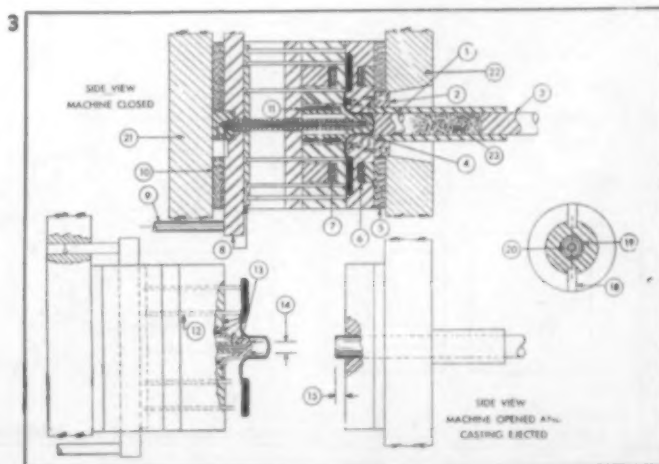
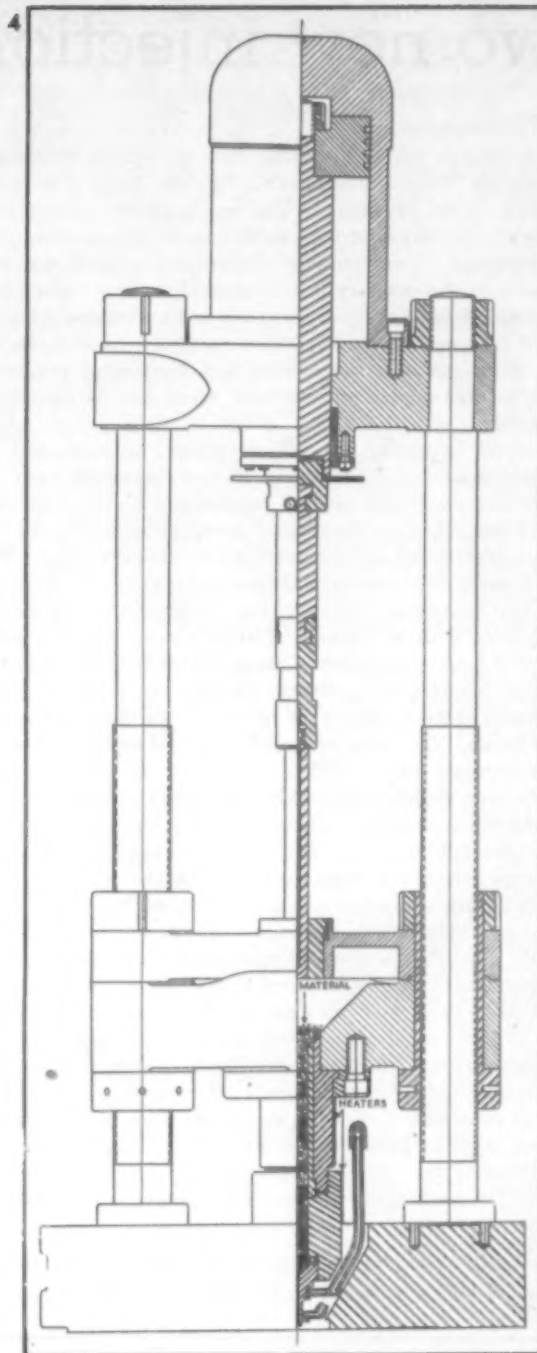
As the die opens, a bumper bar ejects the casting, along with the runners and possibly a thin injection-cylinder disk or slug. The entire process consumes from one-third to one-fifth the time required for compression molding, depending upon section thickness in the casting. A better casting is obtained because the material is uniformly heated throughout and is not dependent upon surface or contact heating which may tend to cure at the surface and which may limit heat flow into, and thus the cure of, the interior of the casting.

In addition to the considerable reduction in curing time, this method of heating and molding results in lower acetone extraction, lower stress upon the mold, reduction of stresses within the casting, and therefore less cracking and warping. It also enhances the possibility of molding sections whose thinness has in the past ruled them out for, because of the easy material flow, thinner and deeper wall sections are now simple molding jobs. In general, injection molding broadens the field of plastic molding because it renders feasible many jobs which in the past were given up as too large, complicated or difficult.

Where structural strength is required in heavy castings, it may be possible to use a cheaper material of lower impact value and still obtain castings of high quality by the use of injection molding.

Jet molding of thermosetting material is accomplished on the Lester Model 3V-12 machine by the patented process of introducing granular material into a heating cylinder where it is first plasticized by resistance heaters, as is usual in the molding of thermoplastic materials. Then, at the moment of injection, the plasticized material is forced through a short, small-diameter nozzle which is heated to a high temperature by low voltage, high-amperage current in such a (Please turn to page 194)

3—Legend for the accompanying drawing. Side view, machine closed: 1) Plunger at end of injection stroke; 2) cylinder retainer; 3) plunger; 4) water hole to prevent set-up in cycle; 5 and 10) insulation; 6) injection half heaters; 7) ejector half heaters; 8) ejector plates; 9) machine ejector rods; 11) sprue core heater; 21) movable die plate; 22) molding machine stationary die plate; 23) material. Side view, machine opened and casting ejected: 12) ejector pins; 13) hot runners to preheat material and partial set-up en route to cavities; 14) cold area to prevent set-up in cylinder; 15) plunger moves forward to this position as mold opens, removing runners and slug from injection mold half and cleaning cylinder. Drawing at extreme right of figure represents section "A-A" of side view of machine when closed: 18) same number of sprue core runners as cavities; 19) outside water tube; 20) inner water tube. 4—Partial cutaway section of the new vertical injection machine showing the location of the injection piston, the material, the material heat elements and several other components



# Two new injection machines

**T**O keep pace with the many new and improved plastic materials, Watson-Stillman Co., Roselle, N. J., maintains a laboratory for the development and testing of its plastic molding equipment to ensure that the machines meet the manufacturing requirements of these materials. Before any piece of apparatus is released to the industry it is thoroughly tested under conditions comparable to those encountered in any production plant, and test runs are made on various plastics to ensure the purchaser of the machine satisfactory and dependable production of parts in the range of materials for which any particular unit is designed.

New fully hydraulic injection machines, both vertical and horizontal, can be said to be the product of this extensive laboratory development and of the breakdown runs. Experience gathered from the performance of previous machines and from molders' suggestions as to what is most desirable in machines of this type, is also reflected in this equipment.

The new horizontal machine (Fig. 1) is available in 5 sizes, ranging from 6 to 24 ounces. The hydraulic clamping platen moves on 4 forged-steel rods of ample dimensions and is bronze-bushed to insure perfect alignment with the injection platen. It advances at high speed and automatically slows down prior to die contact. On the return stroke, platens separate slowly to a predetermined point which is controlled by a timer. Then they continue rapidly, but again slow down before contacting the knockouts. A definite clamping capacity is assured through the use of a holding pump whose pressure is adjustable over a wide range without any connection with the injection power unit. Accurate adjustments for the varying mold thicknesses required in mechanical clamping are said to be eliminated, and it is understood that hobbing of molds due to excessive clamping pressures can be definitely overcome.

In previous designs of this type, the deflection in the injection platen at the nozzle opening has been a troublesome problem to many molders. To bring this deflection to a minimum, the injection platen of the new machine has been greatly strengthened and is so constructed that bushings of various sizes can be installed to vary the guide bore to suit the guide boss of the mold.

The heating cylinder has been greatly improved, and its efficiency is reflected in the reduced horsepower that is required

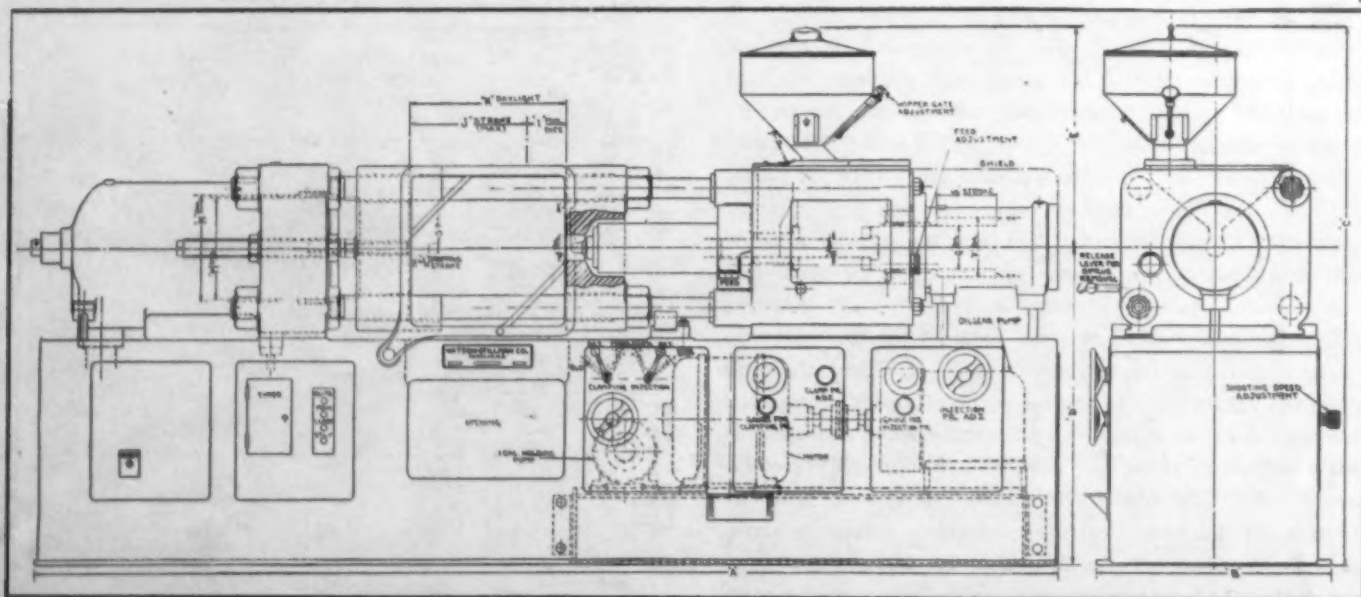
for the injection of the material and in an increase in the amount of material plasticized per hour. Pre-heating of the plastic takes place within the heating cylinder prior to the point at which the material contacts the heated torpedo. As a result, a desirable nozzle pressure is achieved in this model. In each machine there is a choice of 3 to 4 sizes of heating cylinders at varying injection pressures. Controlled zone heating, improved by laboratory test, gives efficient and economical operation. The entire hydraulic power unit, which consists of 2 pumps, hydraulic controls and an oil tank, is mounted on a common base. This arrangement permits ready removal from the machine if servicing is required. This horizontal machine is designed to meet the requirements for the molding of all thermoplastic materials that are in use today, and is designed to be readily converted to the molding of thermosetting materials.

A new vertical injection-molding machine (Fig. 2) is obtainable in 2 and 4 oz. capacities. The machine is constructed so that the standard 2-plate mold or a single top die with 2 bottom dies can be used. This feature permits the operator to position inserts in one of the bottom dies while the other die is in the molding position, thus giving the maximum injection cycles per minute. The unit is therefore able to handle thermoplastic parts requiring inserts without loss of time for positioning.

The machine bed and C-frame of the vertical machine is a single-piece welded-steel structure which contains the entire power unit including the control apparatus—both electric and hydraulic. The clamping of the mold and the injection of the material are accomplished by the one motion of the main ram. The mold halves are first clamped. Then they are brought into contact with the injection nozzle carrying the upper half of the mold. The injection cylinder is brought into contact with the stationary injection ram for the injection of the material. A top hydraulic cylinder connected by rods to the top mold platen controls the injection pressure and can be adjusted to any desired pressure within the range of the machine. With this method of molding, the machine is readily adaptable for transfer molding of thermosetting materials.

Over a wide range of sizes, these machines will advance at a rate of 220 in. per min. and return at the same speed. Limit controls regulate the speed of operation in the advance of the

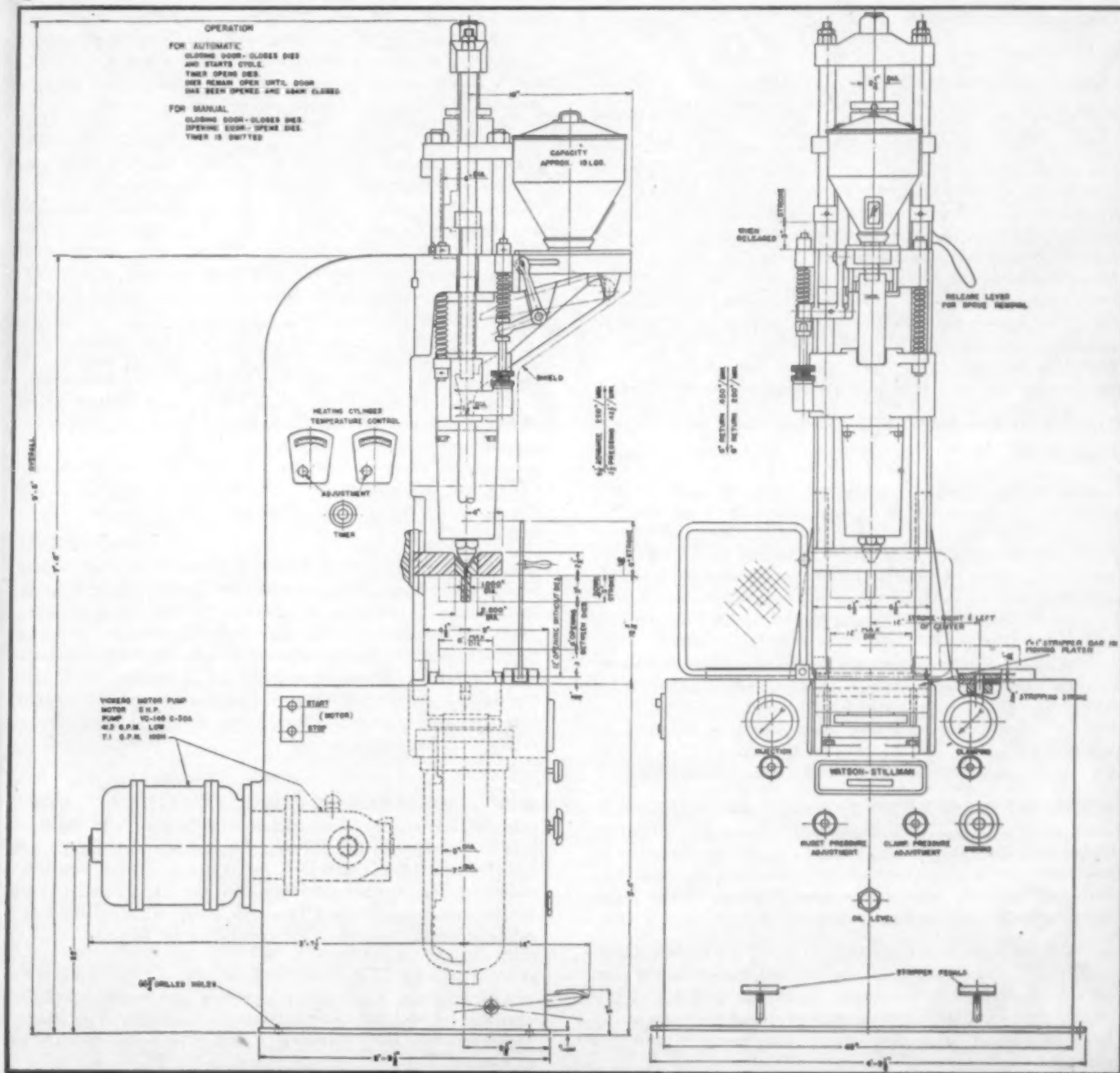
1—The fully-hydraulic horizontal machine is available in 5 sizes, ranging from 6 to 24 ounces. 2—This drawing shows details of the 2-oz. vertical injection molding machine



Fully automatic machines in 25-, 50- and 75-ton capacities are said to be highly economical production units for the manufacture of compression-molded thermosetting parts not requiring inserts. With centralized control this machine will complete all molding operations including degassing with but occasional attention by an operator. Material is fed automatically into an adjustable loading board which deposits its charge into the mold cavity where the molding is completed, and from which the parts are removed through the use of an air jet to a bin outside of the machine. When the molding cycle is completed, mechanical fingers inspect the cavities and force plugs to make sure

### SPECIFICATIONS FOR VERTICAL INJECTION MACHINE

	<i>2-oz. machine</i>	<i>4-oz. machine</i>
Capacity of hopper, lb.	18	24
Clamping stroke max., in.	12	15
Clamping capacity in tons	20	50
Maximum cycles per min.	7	7
Daylight opening, in.	12	12
Maximum die sizes (see platen layout), in.	6 × 12	8 × 12
Motor h.p. (total)	5	10
Floor space	4 ft. 8 in. × 4 ft.	5 ft. 6 in. × 4 ft. 6 in.
Over-all height	9 ft. 7 1/4 in.	11 ft.



# BOOKS AND BOOKLETS

Write directly to the publishers for these booklets. Unless otherwise specified, they will be mailed without charge to executives who request them on business stationery. Other books will be sent post-paid at the publishers' advertised prices.

## Emulsion Technology, Theoretical and Applied

Chemical Publishing Co., Inc., Brooklyn, 1943

Price \$5.00

290 pages

The papers presented at the Symposium on Technical Aspects of Emulsions, held in London in 1934 by the British Section of the International Society of Leather Trades' Chemists, are reprinted in this book with certain revisions. There have been included 3 additional chapters written by American specialists in this field. They are: "The Fundamental Principles of Practical Emulsion Manufacture" by R. M. K. Cobb; "Industrial Emulsion Formulation" by M. P. Hofmann; and "Emulsion Paints" by S. Werthan.

G.M.K.

## Practical Emulsions

by H. Bennett

Chemical Publishing Co., Inc., Brooklyn, 1943

Price \$5.00

462 pages

This handbook on emulsions, emulsifiers, and the formulation and preparation of industrial emulsified products, has concentrated in it a great deal of practical information. Part I includes a general treatment of the technology of emulsions and lists emulsifying, dispersing, wetting, demulsifying and defoaming agents. Part II gives formulas and directions for making various industrial emulsions, such as lacquer, resin, rubber and wax emulsions, to name a few. It will be useful to anyone concerned with the field of applied emulsions.

G.M.K.

## Rubber Red Book:

### Directory of the Rubber Industry, 1943 Edition

The Rubber Age, 250 W. 57th St., New York, 1943

Price, \$5.00

579 pages

As the editor explains in his foreword, every section of this 1943 edition of the Rubber Red Book necessarily reflects wartime conditions. However, in an effort to make available information which will be needed as soon as restrictions are raised, the directory lists a number of materials which are at present unobtainable and many manufacturers whose activities have been temporarily suspended. Rubber products of a strictly military nature have been omitted.

In addition to the materials, manufacturers and machinery sections, the directory contains lists of consulting technologists, trade and technical organizations and a who's who of the industry. A timely feature is a brief article by M. B. Shepard, development manager, Naugatuck Chemical Div. of U. S. Rubber Co., on the place of the reclaiming industry in the war effort.

★ THE MANUFACTURE OF A NEW CONVEYOR-ELEVATOR system to be known as Rex Uni-Flo is announced by Chain Belt Co., Milwaukee, Wis., in a new brochure. This conveying unit is of the continuous-stream type, composed of a chain-belt equipped with closely spaced scraper-carrier flights which operate in an enclosed casing.

★ "BULLETIN 1100," RECEIVED FROM % PROPORTIONERS, Inc. %, Providence, R. I., contains information on the company's equipment for continuous automatic proportioning of fluids. This practical handbook of proportional feeding is attractively illustrated with photographs and many helpful flow diagrams.

★ "PHENOPREG," A PUBLICATION ON PHENOLIC impregnated laminating materials, has just been released by Detroit Wax Paper Co., River Rouge, Mich. This company specializes in the specification treatment of fabrics, sheetings and paper with phenolic resin varnishes. Laboratory control, slitting and impregnating equipment and types of processing such as roll-feed, die-cutting and low-pressure molding, are discussed. A section is devoted to phenopreg materials and the weight and physical values of phenopreg grades. Materials described include bootleg duck grades, enameling duck grades, sheeting paper grades, tube winding paper grades, plastic paper, bonding material and specialty grades.

★ THE 1944 EDITION OF THE CLASSIFIED DIRECTORY of consulting chemists and chemical engineers, compiled by the Association of Consulting Chemists and Chemical Engineers, Inc., New York, N. Y., has just been distributed. Highlights of this edition include a new and more practical layout, the addition of a foreword and guide for using the directory, and excerpts from the code of ethics and by-laws of the association.

★ CONTINENTAL MACHINES, INC., MINNEAPOLIS, Minn., has issued a new pocket-size handbook on scientific inspection entitled "Quality Control." The book deals briefly but comprehensively with the entire subject of precision measurement and describes the many instruments developed to interpret fine dimensions. Application photographs and tables pertaining to gaging methods are also included. A question and answer section at the end of the handbook tests the knowledge gained from a study of the contents.

★ FEDERAL SPECIFICATION L-P-406A, "PLASTICS, Organic: General Specifications, Test Methods," has been issued by Government Printing Office. This revision has been expanded to approximately 3 times the size of the original specification and includes test methods for mechanical, thermal, optical, electrical, permanence, chemical and miscellaneous physical properties. Copies can be obtained from the Supt. of Documents, U. S. Government Printing Office, Washington 25, D. C., for 15 cents each.

★ A NEW AND ENLARGED THERMOCOUPLE DATA book and catalog, Bulletin S2-4, just published by Wheelco Instruments Co., Chicago, Ill., contains data describing products, prices and recommendations for thermocouple users and suggesting substitutes for restricted materials. The latest amendment to WPB's Conservation Order L-134 is included, and information is given on the selection of thermocouples, lead wire, protecting tubes, heads and insulators. Temperature conversion tables, millivolt tables and tables on pipe and wire sizes help to clarify the text.

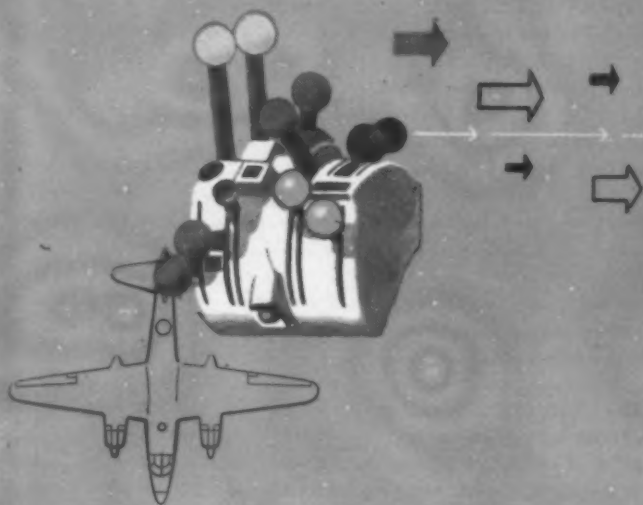
★ A NEW 144-PAGE CATALOG ENTITLED "CHEMICALS by Glyco" contains numerous additions not found in previous catalogs of Glyco Products Co., Inc., Brooklyn, N. Y. It includes a number of plasticizers for synthetic rubber, synthetic resins, etc., and further information on the esters manufactured by the company. The usual features, formulae, suggestions and tables of useful chemical and physical data, are retained.

★ A FOLDER FILE CONTAINING ILLUSTRATIONS and descriptions of plastics engineering and molding facilities available for postwar product development is offered by Plastic Manufacturers, Inc., Stamford, Conn. The folder is made to fit a standard 8 1/2 x 11-in. file drawer.



# Where do plastics fit in the machine field?

Many parts of many machines serve better when made of plastics—  
here is an important plastic market for alert fabricators



To you engaged in plastics fabrication, the broad field of machine construction holds many opportunities. Perhaps you have already recognized these possibilities—and are now making plans for such expansion. Let's consider some practical developments.

Control handles—important parts of nearly every machine—can often be substantially improved when made of certain plastic materials. For example, Ethocel (Dow Ethylcellulose) offers an interesting combination of light weight, toughness, warm "feel" and color permanence. These qualities have proved their value in aircraft control knobs (illustrated left above) where rapid identification, durability and dependability are of prime importance. Applied to

machine control handles, these same advantages result—improving both appearance and actual operation of the machine.

Machinery manufacturers can likewise use plastics for many other parts—such as housings, name plates, chemically-resistant tubing, instrument panels and guards—giving equipment new service ability and new sales appeal. It's an important postwar market that warrants keen attention. We'll be glad to work with fabricators whenever we can be of assistance.

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- ETHOCEL . . . for fabricators producing moldings, extrusions, coatings; available also as Ethocel Sheeting.
- SARAN . . . for fabricators producing moldings, extrusions, pipe, tubing, sheet; available also as Saran Film.

Write for New Dow Booklet "A Practical Approach to Plastics."



CHEMICALS PLASTICS MAGNESIUM

INDISPENSABLE TO INDUSTRY AND VICTORY

# WASHINGTON ROUND-UP

R. L. VAN BOSKIRK, Washington Editor

## Need for vinyl chloride grows to almost unbelievable proportions

Vinyl chloride allocations seem to be getting tighter and tighter each month. Relief is in the offing, but not for several months. Not all the facts can be told about the present shortage because it is closely tied to military affairs that are not public property. Furthermore, vinyl production is largely in the hands of a very few companies and outright discussion of the subject might reveal their competitive position.

Here is as much of the story as we are permitted to know. A new plant was expected to come in last February, but now it looks as though new facilities would not be available until June—and possibly later. Plans had already been made to absorb the new production. When it didn't come in, hasty rearrangements had to be made for the allocation pattern. As a result, many users did not get what they had expected.

Another important and little known angle of this shortage was that a serious crisis developed in the neoprene supply during January and February. Regardless of the cause for this condition, it seemed in February as though production of landing craft and other naval vessels might be seriously delayed. At the last moment, vinyl chloride resins were shoved into the breach to make up the deficit and assure enough cable for the most urgent war needs. The vinyl producers met this unforeseen emergency adequately and are entitled to more credit for this work than has been given them.

Military uses for this utilitarian plastic are almost unbelievable. While no one will confirm the figure, inquiry in important places seems to indicate that somewhere around 80 percent of all the vinyl chloride resins that we produce is going for cable insulation of one type or another. Furthermore it is being used extensively for gun covers, ponchos, raincoats, powder bags, waterproof clothing bags, wet weather parkas, mountain tents, flotation bladders, and many other items that are confidential. It is no secret that there is an insufficient supply of vinyl to take care of all the uses that the Armed Forces would like to make of it, and some military items formerly of vinyl have been discontinued because there were more important uses for the material in other categories. Great Britain and Russia are also cognizant of the value that lies in vinyl plastics products. The U. S. Government deems it advisable to supply these governments with a considerable amount of the plastic for certain highly important military purposes.

Allocation troubles have multiplied because of the extreme flexibility of the various vinyl chloride compounds. One compound can frequently be substituted for another, but when the substitutions are made, manufacturing processes are slowed down until adjustments are made for the different formulations. This same situation sometimes also results in a comparatively plentiful copolymer suddenly becoming tight because it has been substituted for some other copolymer in an emergency.

It is of course important to know that vinyl production has increased tremendously since the beginning of the war. Private companies have put forth every effort to raise their production, but have not had the same kind of government help that has been given for the production of synthetic rubber. Nevertheless, they have made rapid strides on their own initiative and it is only fair to state that priorities for facilities are beginning to be granted in more generous fashion. In this connection it could be noted that the amount of vinyl used for cable alone is many times more than the total amount of vinyl produced by the entire industry just two years ago.

The above explanation is as much of the story regarding the tight position of vinyl chloride, as can be told at the present time.

If, as a user, you can't get all that you want, remember that Uncle Sam is a powerful and potent consumer and his requests must come first, and even in Government requests there are certain items that must have precedence before any vinyl can be allocated to lesser items.

## New price order for all plastics products

The new plastics products price regulation, MPR-153, became effective March 27, 1944. Previous to this date plastics products pricing was ineffective and confusing. The plastics industry's products were controlled by 3 separate regulations. MPR-188 regulated consumer items of all sorts, including such plastic goods as buttons, ash trays, toys and the like. MPR-136 covered machines, machine parts, electrical parts, radio parts, etc., including such plastic products as gears, bearings and panels. GMPR, specifically Order 229, covered parts not mentioned in MPR-136 such as knobs, jewelry and sporting goods.

The new regulation sets up the plastics industry as a separate entity and combines all finished plastics products in one regulation. It will include any product, made in whole or in part of plastics materials, that is produced by molding, laminating, casting or extruding or by other methods of fabrication. The regulation also includes sheets, rods or tubes unless they are produced by a manufacturer who makes and sells the raw materials, in which case they remain under MPR-406.

An important feature of the regulation is that there is no provision for the exemption from price control of so-called war work except in the case of contracts certified by the Government as being either experimental or of a secret nature.

For items which were sold during the period from Jan. 1 to March 31, 1942, the last price at which the manufacturer sold or offered to sell the goods would be the maximum price. The price of items not offered during that period must be computed in accordance with the price-determining method which was in effect in the plant on March 31, 1942. Rates for labor, overhead and profit can be no higher than the rates which were in effect on that date.

Each manufacturer's price-determining method should have been filed with OPA on or before Feb. 19, 1943. If anyone has started a new business since March 1942, he should have filed his price-determining method within 30 days after going into business. Each processor's price-determining method should be filed in simple letter form. The price-determining method is simply a report of each manufacturer's cost-estimating method, and the manufacturer does not have to file individual reports for every item he produces. After he has once filed a report showing his method of estimating and the rates applied in such estimate, he need file no further report as long as he uses the reported method and applies the reported rates to each new item.

Price increases due to faulty estimation of the amount of labor or the amount of material may be obtained by filing a report giving an explanation of the reasons for increases and a comparison of the new and original cost estimate. Such a re-computation based on actual production experience may be made only once. A noteworthy feature of the regulation is that molds and dies which are built for the special purpose of manufacturing a plastic product may be priced to the customer at current costs.

The regulation, which will be rigidly enforced, will be administered by the Machinery Branch, Parts and Subassembly Section of the OPA in which Sidney S. Ullman is the plastics specialist. Mr. Ullman has carried the major load in preparing this regulation, is thoroughly versed in all of its provisions and more than willing to meet questioners. (Please turn to next page)

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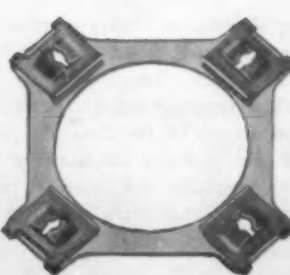
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# Speed Nuts

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In addition to the many standard SPEED NUTS, there are hundreds of other shapes and types designed to perform multiple functions and combine several fasteners into one. These SPEED NUTS, wherever used, reduce the number of parts in an assembly and eliminate the unnecessary handling of extra parts. The patented, self-locking SPEED NUT prongs can be incorporated into almost any shape or design to meet specific assembly requirements. No other fastener possesses such flexibility of design.

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★ FASTEST THING IN FASTENERS

\*Trademark Reg. U. S. Patent Office

### Raynolds resigns from WPB

J. W. Raynolds, Deputy Director of Chemicals Bureau, WPB, resigned as of March 15, 1944, to take a much-needed rest. Mr. Raynolds indicated that he had no immediate plans other than an extended vacation.

W. F. Twombly, chief of Aromatics and Intermediates Section, Chemicals Bureau, since Dec. 1, 1942, will succeed Mr. Raynolds in his capacity as assistant director in charge of the Drugs and Cosmetics, Protective Coatings and Plastics Sections. Before joining WPB, Mr. Twombly was engaged in newspaper work in New England. For 15 yr. prior to his taking over the management of the family paper at Reading, Mass., Mr. Twombly was employed by E. I. du Pont de Nemours and Co., Inc., and the Jackson Research Laboratories.

### Cellulose acetate molding powder and sheeting committee

WPB has recently made public a report from a new plastics industry advisory committee that met last February. We are printing here a few excerpts that are still pertinent. Walter Wagner of WPB Chemicals Bureau served as Government presiding officer.

**Plasticizer distribution**—Members of the committee explained the difficulties encountered in obtaining substitute plasticizers. Rather than use ratings on materials allocated to the industry, as suggested by one of the committee members, a government spokesman suggested that it would be advisable to adopt a plan of distribution whereby manufacturers will share in the available supply of substitute plasticizers on the basis of their molding-powder and sheeting allocations. He also pointed out that the allocation of all types of plasticizers does not seem desirable because of the probability of change in the supply situation.

**Substitute materials for plasticizers**—In discussing the use of substitute plasticizers, Mr. Wagner told the committee that the Chemicals Bureau would consider appeals for the use of phthalate in instances where manufacturers encounter production difficulties in making items for which the use of phthalate has been denied. The Army and Navy are willing to consider changes in specifications to permit the use of substitute materials wherever it is feasible. The Plastics Section will assist manufacturers in attempting to have Armed Service specifications changed when these problems are brought to its attention.

**Order M-326**—George H. Sollenberger explained that the basic restrictions of Order M-326-a were not changed by the Feb. 24 amendment. The 3 major changes effected were explained: 1) A change in the definition excludes all substandard material. Short lengths, narrow widths and second-grade sheets are not controlled by the order. 2) Manufacturers are permitted to apply for an allocation of material earmarked for emergency shipments against military contract orders. 3) Provision has been made for aggregating aircraft sheet orders instead of making separate entries for each purchase order.

**Flake**—Flake for molding powder is now being allocated to inventory in a lump amount rather than by type. Manufacturers will have an opportunity to stock-pile flake by applying for quantities to be used pursuant to Order M-326-a and Order M-326-b. Authorization for use will have to be obtained from the WPB. The committee was told that a 75 percent factor is being considered for determining allocations of flake.

### Plastic handles for 2,076,000 electric irons?

The Government's "go-ahead" signal for the production of 2,076,000 electric irons is of more than passing interest to plastics operators. Phenolic handles have come to be accepted as practically standard for electric irons, and the first question that arises is: "Will we get the material to make them or will they go into some other material?"

Contrary to frequently printed reports, this provision for electric irons is in no sense an experiment in reconversion. According to WPB officials, it is definitely a part of the war emergency effort, since irons are one of the most sorely needed items in the domestic economy. Officials point out that the order might be used as a pattern for other durable goods that have a

great many component parts and which are needed almost as much as irons.

Briefly, the pattern seems to contemplate production quotas based on a given number for each company rather than on an industry-wide percentage of some base-period output. Before manufacturers can produce irons they will have to fill out Form WPB 3550.1, and quotas will be set after information provided by the forms has been correlated. The form asks for base period (1940) production, estimated production quantity, present volume of war business, availability of space, and several other items pertaining to the producer's ability to manufacture irons without interfering with war goods production.

This operation may turn out to be complicated and difficult because of the many component parts in an electric iron. Before production of irons can begin, the Government will have to be certain that material for those component parts is available.

The motivating order L-65-a (electric irons) contains at least 2 paragraphs of great concern to plastics processors who might be interested in providing parts for irons. Paragraph (d) reads as follows: "No person other than those authorized to make electric irons on Form WPB 3550.1 shall make any sole plates or handles for electric irons in a Group I labor area except as authorized in writing by the nearest field office of WPB." A Government official interpreted this paragraph to mean that a parts manufacturer located outside a Group I labor area could take an order for phenolic handles without further ado, provided he could get the molding powder.

Similarly an iron manufacturer who makes his own handles would have no trouble obtaining permission to manufacture his product even if he were in a Group I labor area, unless it interfered with his war effort. But if the iron manufacturer wanted to buy handles from a plastics processor who happened to be in a Group I labor area, the processor must first obtain permission to make them from his nearest WPB office. Even if the handles are made in a branch plant and that plant is in a Group I area, it will be necessary to obtain permission from the local WPB office. The complicating factor is that these areas may change from one to the other group according to local conditions.

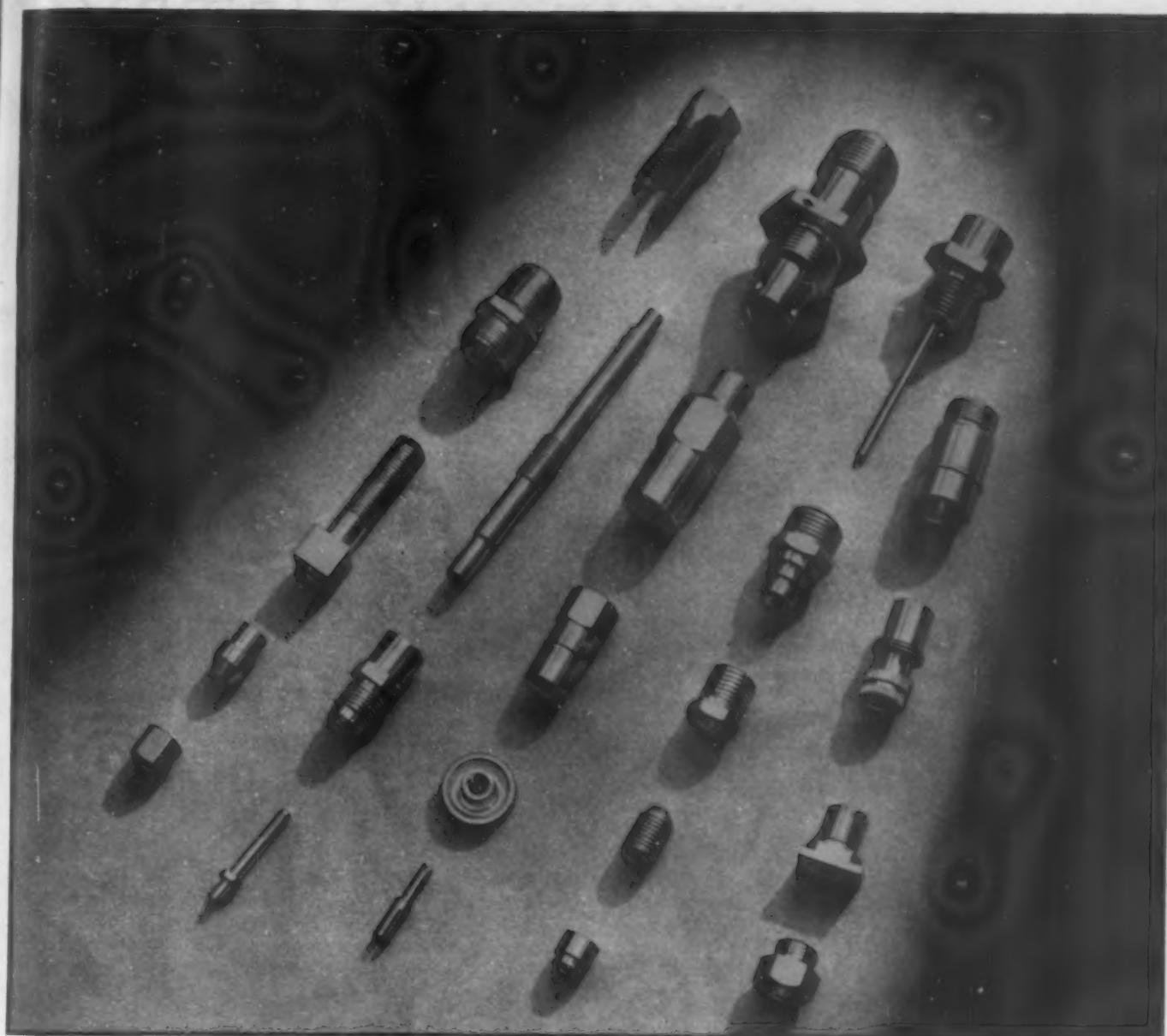
Officials estimate that it will take 1,000,000 lb. of phenolics to fill this order for iron handles unless a larger percentage than usual is made of wood. Substitutes of less critical material have been suggested, but officials are not encouraging anything other than time-tested products.

There is an important paragraph (h) on the electric iron order which says: "this order and all transactions affected by this order are subject to the applicable regulations of WPB. If any other order of the WPB limits the use of any material in the production of electric irons to a greater extent than does this order, the other order shall govern unless it states otherwise."

### Thermosetting laminate price order is issued

The long-awaited pricing order for thermosetting laminated plastic sheets, rods and tubes was issued as MPR-519 and became effective March 21. The order simply puts on record and makes binding the industry's voluntary 10 percent cut which was made last September. It affects only sheets, rods and tubes as listed in the appendix of the order. The order does not include fabricated parts, preforms, gear blocks or similar items. The new order adopts without change the industry's price and discount list as of January 1941, except for minor changes in the list prices of thin sheets which will have the net effect of eliminating some variations in sheet prices that have existed within the industry since the voluntary price agreement went into effect last fall.

This is strictly a raw material order and puts thermosetting laminates in a separate order as distinguished from MPR-406 which includes other plastic materials. There are only minor changes from the rough draft which was submitted to the industry last fall. The chief variation seems to be the experimental limitation which was changed from a dollar valuation of \$2500 to a quantity limitation of 1000 pounds. Adjustments may be applied for under Procedural (Please turn to page 192)



## Plastics and Brass...



If you combine metal with plastics, remember that The Chicago Screw Company is the foremost producer of the highest quality Brass and Steel Screw Machine Products... They have the manpower, the machinery and the "Know How" and whether your problem involves plastics, brass or steel screw machine products including secondary operations—our experience, engineering ability and modern production facilities warrant your serious consideration.

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# NEWS OF THE INDUSTRY

★ **THROUGH THE ACQUISITION OF I. F. LAUCKS, Inc.,** of Seattle, Wash., Monsanto Chemical Co. has entered the West Coast industrial field. Charles Belknap, president of Monsanto, and H. P. Banks, vice-president and general manager of I. F. Laucks, Inc., made the announcement of the purchase. Monsanto will acquire the 2 Laucks plants in Seattle and other company interests at Vancouver, B. C.; Los Angeles, Calif.; Portsmouth, Va.; Lockport, N. Y.; and Stanbridge, P. Q., as well as in Australia and Sweden.

★ **INDUSTRY RECEIVED ITS FIRST DEFINITE INDICATION** of the possible postwar price trend in plastic materials when Dow Chemical Co. announced a reduction of 3 cents per lb. in the base price of polystyrene molding powders. This reduction, which became effective March 10, is the first major price change since November 1942.

★ **THE AMERICAN CYANAMID CO. HAS ANNOUNCED** a reduction in the price of its mineral-filled melamine formaldehyde molding materials which will become effective April 1. On the new price schedule the cost of this material is graduated from 55 cents for less than 1 drum to 50 cents for 20,000 lb. and over.

★ **THE 1944 WILLIAM H. NICHOLS MEDAL OF NEW York Section of American Chemical Society,** one of the highest awards in chemical science, was presented to Dr. Carl Shipp Marvel, professor of organic chemistry, University of Illinois, for fundamental research advancing knowledge in synthetic rubber and plastics. Dr. Marvel was also cited for his research in the structure of sulfur-dioxide-olefin polymers. The award was presented by Dr. William W. Winship, chairman of the jury of awards. Dr. Marvel is recognized as one of the outstanding authorities in this country in organic chemistry, especially in the field of polymers, and for his extensive knowledge of organic chemical reactions.

★ **H. W. DEVORE, WHO HAS BEEN WITH PLASKON Div.,** Libbey-Owens-Ford Glass Co., for the past 12 years, has left that company to become plastic engineer and director of production for Patent Button Co. of Tennessee, Inc., Knoxville, Tenn.

★ **CELANESE CORP. OF AMERICA HAS ORGANIZED A** new unit, the Celanese Chemical Corp., to handle the sale of various chemicals manufactured at the company's plants. Among the chemicals produced, or expected to be produced, are butadiene, pentaerythritol, hexamine, formaldehyde, methanol, tricresyl phosphate, triethyl phosphate, triphenyl phosphate, triethyl citrate, tributyl citrate, diethyl phthalate, dyestuffs for cellulose acetate and muriatic acid. In line with the organization of this division, the corporation has commenced construction of a chemical plant at Bishop, Tex.

★ **AT AN EXECUTIVE COMMITTEE MEETING OF THE** Detroit Rubber and Plastics Group, the following officers were elected for 1944: F. H. Wehmer, chairman; J. C. Dudley, vice-chairman; E. J. Kvet, secretary-treasurer; J. P. Wilson, program; J. R. Schroyer, entertainment; W. J. McCourtney, counselor; J. W. Temple, publicity; A. J. Kearfott, membership; W. E. Biggers and F. F. Riesing, executive committee, and W. J. Phillips, educational committee.

★ **HONORARY DOCTORATES IN ENGINEERING WERE** awarded to Willard H. Dow, president of Dow Chemical Co., and James A. Rafferty, president of Carbide and Carbon Chemicals Corp., by Illinois Institute of Technology. Mr. Dow was cited

for "major contributions to the production of magnesium, synthetic rubber, bromine from sea water, phenols and other vital products used in war and in peace," and Mr. Rafferty for "engineering ability, industry, vision and leadership displayed in the organization and direction of one of America's greatest chemical enterprises."

★ **IN RECOGNITION OF EMINENT WORK IN AND** original contributions to pure and applied chemistry, Dr. George O. Curme, Jr., vice-president and director of research of Carbide and Carbon Chemicals Corp., has been awarded the 1944 Willard Gibbs Medal. This award is one of the highest distinctions in chemical science and is given annually by the Chicago Section of American Chemical Society.

★ **C. A. HEMINGWAY HAS BEEN ELECTED VICE-** president of Witco Chemical Co. He will continue as head of the Cleveland office where he has been in charge of sales of Witco products. C. J. Minnig has been appointed vice-president of Witco Chemical Co. He will direct the sales of the company's lines of Witco and Continental carbon blacks from his office in Akron, Ohio.

★ **BERNARD SCHILLER HAS RESIGNED FROM UNI-** versal Plastics Corp., and joined with R. D. Werner of R. D. Werner Co., Inc., to form the Ardee Plastics Corp.

★ **CHARLES J. SMITH, SUPERINTENDENT OF PLAS-** tics Division of Bryant Electric Co., Bridgeport, Conn., was presented with the Westinghouse Order of Merit for outstanding performance and devotion beyond the ordinary call of duty. The certificate of citation accompanying the award reads as follows: "For his ability and resourcefulness in the production of plastic molded articles, for his many contributions during the pioneering period of the company's plastics development, and for skill in meeting the trying problems of war production."

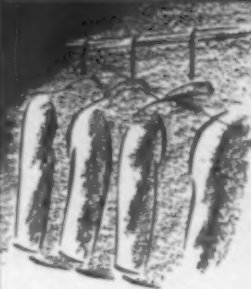
★ **FREDERICK H. HEISS, CHEMIST, CALCO CHEMICAL** Div., American Cyanamid Co., has been transferred from the company's home offices at Bound Brook, N. J., to the Chicago sales office, where he will be concerned with the sale and service of the company's products to paint, printing ink and pigment consumers.

★ **C. W. MARSELLUS HAS BEEN APPOINTED DIREC-** tor of sales at Universal Plastics Corp. As of May 1, 1944, the executive offices of this corporation will be located at Room 2210, 350 Fifth Ave., New York City.

★ **M. D. TUCKER, VICE-PRESIDENT OF EVANS PROD-** ucts Co., Portland, Ore., has purchased from Evans Products Co. its Lebanon, Ore., fir plywood plant, said to be the largest and most modern plywood plant in the world. Mr. Tucker has organized the Cascades Plywood Corp. to operate the Lebanon plant and will function as its president. Simultaneously, it was announced by Mr. Tucker and Lawrence Ottinger, president, U. S. Plywood Corp., that a contract has been signed for the sale of the entire production of Cascades through the distribution facilities of U. S. Plywood. The entire output will be manufactured and marketed under U. S. Plywood's Weldwood plywood process and brand.

★ **THE PLANT AND OFFICES OF WRIGHT PLASTICS,** Inc., have been moved to 4625 Third Avenue, Bronx, N. Y.

*(Please turn to next page)*



# NORTON LABORATORIES

(INCORPORATED)  
CUSTOM MOULDERS OF SYNTHETIC PLASTICS  
BAKELITE DUREZ

LOCKPORT, N.Y.

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NOVELTIES

ALL AGREEMENTS ARE CONTINGENT UPON STRIKES, FIRES, ACCIDENTS OR CAUSES BEYOND OUR CONTROL.  
CONTRACTS WITH AGENTS NOT VALID UNTIL APPROVED BY AN OFFICER

April 6, 1944

Dear Molded Plastic Users:-

You know how many retail clothing sales people will tell you that you look marvelous in any suit in which you express the slightest interest.

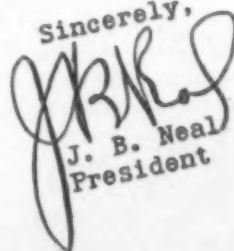
Well, there's a temptation to do likewise with molded plastics. We might tell you, "you'd look pretty with a molded henhouse", and probably you would, but we're not going to try to sell you one.

We want you to buy molded plastics from us on a sound basis. The item we sell you should be the correct material for the purpose, honestly made of top quality compound to give you lasting satisfaction.

It's snowing here while I'm writing this, but by the time you read it, our apple blossoms ought to be out. We always thank the man who had the foresight to plant those trees so we can see the blossoms and eat the fruit.

New blossoms are coming in plastics. It's a good time right now to set out a few trees for post-war bloom.

Sincerely,

  
J. B. Neal  
President

★ THE NEVILLE CO., PITTSBURGH, PA., HAS DEVELOPED a material called PHO designed to relieve the shortage of the extremely critical materials forming the usual plasticizers for cellulose acetate. Up to 50 percent of the usual expensive plasticizers, such as triacetin and the phthalic and phosphoric esters—all extremely difficult to obtain under present restrictions—can be replaced by this material. It is a viscous, resinous liquid. Therefore, total plasticizing oil content of compositions employing it, is somewhat higher than that obtained with ordinary plasticizers.

★ MEYER AND BROWN CORP., NEW YORK, ANNOUNCE appointment of Philip Nelson Felleman as vice-president. For over 18 years Mr. Felleman was associated with H. Muehlstein & Co., Inc. As of April 1, Meyer and Brown Corp. will engage as dealers in scrap rubber, synthetics and plastics in addition to their usual business of servicing Rubber Reserve Co. permits for crude and synthetic rubber.

★ ELECTRICALLY CONDUCTIVE COATINGS, APPLICABLE to a wide variety of non-conductors such as glass, plastics, porcelain, soapstone, wood, cloth and paper, are being produced by Electrochemicals Dept. of E. I. du Pont de Nemours & Co., Inc. These dull metallic gray coatings are manufactured by the use of a ceramic-type composition and can be applied by spraying, dipping or brushing, followed by air drying and, in some cases, baking. They contain silver powder which produces a surface of low electrical resistance and high conductivity, making them valuable for use in electrical condensers and other units employed in electrical circuits, and are only slightly affected by exposure to sulfides. The coatings are being manufactured for commercial use and can be obtained in several different formulations, including a thermoplastic conductive cement, conductive coated cloth and flexible conductive film. While the formulations are not as yet being produced commercially, they are available as laboratory samples for evaluation purposes.

★ WALKER CHEMIPLAST CORP., A NEW ORGANIZATION of consulting chemists and engineers specializing in plastics, has opened its offices at 114 East 32nd St., New York City. This corporation offers full or part-time service in all matters relating to chemical surveys, research and new development, process and methods, product design and planning, production and supervision. Officers of the corporation are: Irving J. Walker, president; C. Thomas Polucci, vice-president; Maurice Finston, secretary; and Benjamin Meier, treasurer.

★ SODIUM CARBOXY-METHYL-CELLULOSE, A CELLULOSE derivative which is soluble in water and is both a stabilizer and emulsifying agent, has been introduced by Cellulose Products Dept., Hercules Power Co., Inc. At present the chemical is in small-scale production and is available in experimental quantities only. According to the company, "the material should be useful where hydrophilic colloids possessing marked suspending, thickening, stabilizing and film-forming properties are required."

★ HAVING JUST COMPLETED A SHOWING AT THE Stamford Chamber of Commerce, Stamford, Conn., the MODERN PLASTICS travelling exhibit moves on to Oklahoma City, Okla., where it will be shown at the Oklahoma City Chamber of Commerce from May 1 to 20 inclusive.

★ SCIENTISTS OF GOODYEAR RESEARCH LABORATORY, Goodyear Tire & Rubber Co., Inc., have developed a new and simple method for bonding wood to metal which may result in revolutionary and far-reaching improvements in the design of building interiors, homes, furniture, airplanes, automobiles, railway cars and ships. It is understood that by means of this new adhesive, named Pliobond, it is possible to cement a layer of plywood only  $\frac{1}{4}$  in. in thickness to a metal surface. The metal sheet may then be handled as usual, and can be bent into any chosen shape or form without cracking the wood or pulling it loose from the metal. Advantages of such bonded materials arise from the fact that they combine the tensile strength, ease of working and fireproof qualities of the metal with the beauty of the wood that is bonded to it. (Please turn to page 194)

## SPEECHES OF THE MONTH

★ AT THE MONTHLY MEETING OF THE RUBBER AND Plastics Div., Society of Chemical Industry, held at McGill University, Dr. Norman S. Grace, manager of Technical Service, Polymer Corp., spoke on the manufacture of synthetic rubber in Canada. He traced the history of the Sarnia plant which was started in June of 1942, and began production of Buna S rubber the following September, using butadiene imported from the United States. Dr. Grace said that this plant, which cost 48 million dollars, can produce 34,000 long tons of Buna-S and 4000 long tons of Butyl per year. It is the only synthetic rubber plant where styrene, butadiene and isobutylene as well as Buna-S and Butyl are produced. Dr. Grace illustrated his talk with slides showing various stages in the construction of the plant and the processing of the raw material into Buna S and Butyl rubber.

★ GEORGE K. SCRIBNER, PRESIDENT OF THE SOCIETY of the Plastics Industry, and Dr. Frank Schoenfeld, director of technical operations and development, Chemical Div., B. F. Goodrich Co., were 2 of the speakers at the afternoon session of the "Fact Forum for the Future" which was conducted by Industrial Marketers of New Jersey at Hotel Essex House, Newark, N. J., on March 21.

After discussing the success of various applications of synthetic rubber, Dr. Schoenfeld in his speech on "Problems of Synthetic Rubber," considered the position of rubber in the postwar era from the point of view of production and cost. In his opinion, with future demand probably exceeding supply, a low cost policy is advisable. Dr. Schoenfeld suggested that now is the time for fact finding and the time to formulate and adopt policies that will assure an unfailing supply of rubber in the future and create the greatest number of postwar jobs.

George K. Scribner opened his talk on "Plastics" with a concise description of the various types of plastics and their uses. The speaker then turned to the history of these materials and to a brief discussion of equipment employed in the production of plastic products. Mr. Scribner took issue with those who speak of the "coming plastics age." He expressed the opinion that while many articles are made entirely of plastics, the materials' most important role will be its use in conjunction with other materials.

★ "RESIN ADHESIVES AND THE NEW PLYWOOD Program" was the subject of an address delivered by Thomas D. Perry, development engineer, Resinous Products & Chemical Co., before the National Chemurgic Counsel at St. Louis, Mo., on March 29. After touching on the development of resin adhesives and their special qualities, Mr. Perry discussed the characteristics and operational techniques of these materials under the headings of "phenolic resins," "urea resins" and "other resins." The speaker also devoted a portion of his talk to the application of resin adhesives.

★ "CELLULOSE PLASTICS" WAS THE SUBJECT OF THE address delivered by P. F. Robb, Hercules Powder Co., Inc., before St. Louis Section, American Chemical Society, on March 6. The speaker described the processes by which cellulose derivatives can be produced from purified cotton linters and chemical wood pulp, 2 economical raw material sources. After listing properties of nitrocellulose plastics, Mr. Robb mentioned an impressive list of war applications of this material. He spoke of the development of cellulose acetate for molding compounds and the mounting interest in acetate plastics and other cellulose derivatives. The speaker concluded with a list of products molded of cellulose acetate butyrate and a description of ethyl cellulose.

# The Munising Paper Company

GENERAL SALES OFFICES • 135 SOUTH LA SALLE STREET • CHICAGO, ILLINOIS

## ARE WE MOVING TOO FAST?

At heart, perhaps, many manufacturers dislike industrial change. It is easier to continue the old methods of manufacture, to contact the old customers, and to keep to the old standard products.

The plastics industry, however, has not yet had time for complacency. Drastically new improvements in raw materials, rapidly advancing manufacturing methods, constantly enlarging sales horizons - and over all a forced-draft production schedule since the war's beginning have advanced the industry at an accelerated rate undreamed of a few years ago.

Is there inherent danger in this rapidity of growth? Is the industry moving too fast to have time for the meticulous attention to manufacturing details that would normally be given? For instance, in the development of laminates some medium was needed to carry the resin and add certain properties to the finished product. Paper was tried and for some uses it worked and was adopted. But paper was paper, period. It soaked up resin and in a general way did the desired job.

Yet there are probably as many variations in the properties of different papers as there are in the formulations of resins. Is it possible that the available variations in caliper, porosity, fiber length, or pH might be used more effectively? Is the industry being satisfied with a paper that merely works, without bothering to explore further?

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## Economical tooling

(Continued from page 128) quired for aircraft production. In general, however, the transfer molding process is not applicable to the production of thin parts having large area. Such parts must be fabricated by laminations because of the reluctance of the molding compound to flow a great distance in a thin section without curing, and because reinforcing, high-strength filler materials cannot be used in the transfer process. Suitability of zinc alloy for high- and low-pressure laminating has not yet been conclusively demonstrated.

In order to explore the above possibilities, it was decided to develop a typical section of the Lockheed Lightning main landing gear door, utilizing an inner skin frame construction. For reasons of economy, only a 2-ft. section along the length of the inner skin frame was molded. However, this piece contained segments of boxes and formed sections typical of the door along its entire length.

In part, the object of this experiment was to demonstrate that numerous components such as aircraft doors and door frames, cowl and coolant flaps, control surfaces and floors, can be molded on Kirksite tooling which is identical to the tooling required to form these parts from sheet metal with the exception of 1) the application of heat to the mold and 2) the elimination of a draw ring. These tests were also designed to show that fractional components of assemblies such as inner skin frames for doors could be formed from available plastic materials, and that more severe drawing and forming than is possible in sheet metal fabrication could be accommodated in such designs. The use of a cold-setting, contact-pressure synthetic resin cement for use in the assembly of inner skin frames to the outer skin in door structures was also studied and demonstrated.

A zinc-alloy laminating mold was cast from plaster patterns. New metal was used in order to avoid surface pitting due to gas formation and inclusions. The castings were blued in roughly, scraped and finished in the conventional manner. Both the punch and the die were flycut to produce parallel

backs for mounting the die in the press. The surface finish of the zinc alloy and the mold installation in the 300-ton hydraulic press may be seen in Fig. 5.

The mold was electrically heated to 315° F., lubricated with a dust coat of zinc stearate, wiped with cheesecloth and inspected for cleanliness. Each of the materials listed in Table III was cut to 20 × 24 in., stacked to the estimated requisite thickness (based on the bulk factor of the material) and then laminate molded.

The laminating operation consisted of opening the mold about 3 in., or enough to slide the sheets of material into place, closing the mold as rapidly as possible (to full estimated pressure), "breathing" to allow the entrapped volatile to escape by momentarily releasing the pressure, applying the molding pressure and maintaining that pressure through the curing cycle. The cure time varied from 3 to 5 min. depending upon the material, the number of layers, etc. The parts were ejected by opening the press and lifting the parts from the mold.

After routing out the bottom of the "pans" (Fig. 6), the molded frame was cemented to the outer skin using Resin-X<sup>5</sup> cold-setting furfural resin (with a small amount of inhibitor present). The outer skin consisted of a piece of reformed grade CH-Formica phenolic laminate, 0.060 in. thick. The reforming was accomplished by heating the laminate for 1½ min. at 475° F., then draping the momentarily replasticized board over the inner skin frame and holding in contact until the material cooled to room temperature. Several coats of Resin-X were applied to both surfaces to be bonded, and contact pressure was maintained for about 4 hr. by means of lead shot bags. Maximum bond strength was developed in approximately 24 hours.

The products resulting from attempts to laminate the various fillers in a Kirksite mold may be seen in Figs. 7, 8, 9 and 10. The Resin-X double-creped paper formed satisfactorily while all other combinations developed serious wrinkles or tore the filler material. The two cemented door assemblies (Figs. 11 and 12) possessed excellent stiffness and rigidity, and the bond proved very satisfactory.

Inspection showed that no physical alteration had occurred in the zinc-alloy mold, and an indefinitely long life at pressures as great as 2000 p.s.i. may be expected. The 315° F. operating pressure appeared not to have affected the surface of the mold. Kirksite's characteristic self-lubricating, non-adherent qualities to phenolic and cresylic acid resins were again observed. In applications where a highly polished surface might be desired, such a surface could be maintained by the application of a flash coating of hard chromium plate on the zinc alloy.<sup>6</sup> Such a coating would impart abrasion resistance against scratching and make the mold inert to some of the more corrosive resins.

The following descriptions of the laminating and flow characteristics of the various materials which were tested are considered in terms of the resulting products:

**Material A (P-18 Army boot duck)**—While material A laminated satisfactorily, it was noted upon ejection of the piece that the continuous sheets of fabric had failed in tension due to insufficient elongation and flow. In areas where

TABLE III.—MATERIALS USED IN MOLD FOR INNER SKIN DOOR FRAME

Designation	Filler material	Impregnating resin
A	P-18 Army boot duck	XV-16303 low-pressure phenolic resin (Bake-lite)
B	High-strength Mischelich sulfite oriented paper, specimen No. 11, Consolidated Water Power & Paper Co.	Same as above
C	100 percent cotton paper mat, 3/32 in. thick, Byron Weston Co.	No resin
D	Resin X-Crepe paper, black, low caliper, Cincinnati Industries, Inc. (See App. II)	Cresylic acid resin
E	Resin X-Crepe paper, tan, high caliper, Cincinnati Industries, Inc.	Same as above
F	Buna-S cellular board, 3/4 thick, U. S. Rubber Co.	No resin

<sup>5</sup> Resin-X is a synthetic resin developed by John Delmonte, technical director, Plastics Industries Technical Institute. A special grade, identified as "surface coating grade," when used in combination with 1-10 ml. Z-1 catalyst per 100 gr. of Resin-X, has proved to be extremely versatile as a contact pressure cement. Such combinations as phenolic resin products and wood, phenolic to phenolic, MR-1A to MR-1, cellulose acetate to cellulose acetate, or any combination of the above with Buna-S rubber or cellular board, and using only contact pressure, develop excellent bonds without heat. The amount of catalyst determines the life and the cure time of the cement. Resin-X is best stored at 40° F.

<sup>6</sup> Although zinc and aluminum are amphoteric, the Atlas Chrome Plating Co. has successfully electroplated hard chromium on both metals.

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wrinkles occurred, the resin had squeezed out and the fabric pulverized as seen in Fig. 7.

**Material B (CWPP sulfite paper)**—Figure 8 shows that only a minimum flow is obtainable in high-strength oriented spruce paper. This material forms well into shapes which are arrived at by simple folding operations, i.e., angles, z-sections, etc. If a draw ring were used to prevent the formation of wrinkles, the individual lamina would probably fail in tension. Paper products flow in compression only if impregnated with synthetic resin. This fact is apparent upon comparison of Fig. 8 with Fig. 9.

**Material C (100 percent cotton mat)**—Since this test was in the nature of a preforming operation, no resin was incorporated in the sheet. Figure 9 shows that unimpregnated paper possesses little ability to flow. When subjected to 300-ton pressure, some of the folded areas actually hopped into the Kirksite mold.

**Material D (Resin X-Crepe paper)**—The most satisfactory flow characteristics were obtained using a cresylic-acid-saturated kraft paper which had undergone a special treatment so that the resulting product was creped in two directions on the sheet of paper—providing elongation and flow in both directions. Caution had to be exercised to avoid excessive curing as a result of too lengthy a breathing and plasticizing period. By examining Fig. 6 it will be seen that all evidence of both folding and tearing were absent in the laminated-molded part.

**Material E (high-caliper Resin X-Crepe)**—The comments made on material D apply here also, except that fewer lamina are used and the molding pressure is slightly higher (due to lower resin content). The part is shown in Fig. 10.

**Material F (Buna-S cellular board)**—The attempt to reform thermoplastic cellular Buna board was not satisfactory as can be seen in Fig. 13. This failure was due in part to the thickness of the sheet. However, too little tensile strength was the actual cause of material failure during forming. Since these tests were made it has been found possible to form Buna-S cellular board around a simple  $\frac{1}{2}$ -in. radius by heating the material in an oven to 200° F. and quickly draping it over a form. This procedure is limited to simple bends and shallow draws.

## Conclusion

The study on laminating materials and mold development indicates that Kirksite molds are quite satisfactory for laminating various aircraft parts such as doors, fairings and flaps. This conclusion serves to nullify the common misconception that plastic parts necessarily require expensive tooling. Zinc-alloy tooling, identical with the metal forming tools widely used for double-action press work, are suitable for plastic laminating, except for the fact that no draw ring is required. This exception might well prove an economic advantage when comparing the tooling required to form plastics or sheet metal. For applications where severe forming or drawing is required, plastic impregnated filler materials are available which possess more versatility than aluminum alloys. For example, the inner skin frame which was developed could not be produced from 24-SO aluminum alloy even when it was heated to 450° F. Further, no draw ring is required when using Resin X-Crepe paper. This study also showed that plastic assemblies can be cemented from component laminated parts using Resin-X furfural resin (and a catalyst) without heat and with only contact pressure. The material appears satisfactory for assembly of typical door section.

## Bearing strength of plastics

(Continued from page 136) producing a permanent set of 0.2 percent deformation of the hole diameter.<sup>4</sup> Figures 6 and 7 show that the permanent set after loading to a bearing stress producing 4 percent deformation of the hole diameter is 0.6 percent for cellulose acetate and 0.8 percent for fabric-base phenolic laminate. This may be compared with 1 to 3 percent for aluminum alloys.<sup>5</sup> Bond<sup>6</sup> found that the 4 percent deformation test method gave much more satisfactory results than did the 0.2 percent permanent set procedure and, in addition, was easier to perform. The bearing stress producing 0.2 percent permanent set varied from about 4 to 40 percent of the bearing stress at 4 percent total deformation. In view of these considerations, the 4 percent method was retained as standard.

There was little difference in bearing strength at 4 percent deformation using either the wide or narrow specimen and jig (Figs. 1 and 2) for Grades L and C phenolic laminate and polymethyl methacrylate. The data are insufficient to determine whether the difference obtained in the case of cellulose acetate was significant. The ultimate bearing stress was higher for the wider specimens.

For Grade L phenolic laminate and cellulose acetate materials, taken as representative of thermosetting and thermoplastic products, respectively, the bearing strength at 4 percent deformation decreased with decreasing pin diameter and with decreasing edge distance for the same diameter. It was found that approximately comparable results were obtained on these materials for  $\frac{1}{4}$ -in. pin with edge distance ratio of 2.5 and for  $\frac{1}{8}$ -in. pin with edge distance ratio of 5.0. In other words, about the same values were obtained for the same distance in inches from the edge of the specimen to the circumference of the hole. Although no tests were made, it is believed that bearing strength would not increase appreciably with greater edge distances than those given. However, the bearing stress at the ultimate increased with decreasing pin diameter but decreased with decreasing edge distance.

Using the same diameter pin and edge distance, bearing strength and ultimate bearing stress were comparable for both  $\frac{1}{16}$  and  $\frac{1}{8}$  in. thicknesses of Grade L phenolic laminate and cellulose acetate plastic. In the case of the  $\frac{1}{16}$  in. diameter pins in  $\frac{1}{8}$  in. thick phenolic laminate, considerable bending of the pin occurred at high loads. It is not known how much the deformation of the pin may have affected the bearing strength at 4 percent deformation.

Fishbein<sup>6</sup> and de Bruyne<sup>7</sup> also found that the ultimate bearing stress decreased with increasing diameter of bolts for phenolic laminates. Tests on  $\frac{1}{4}$  in. thick cast phenolic material loaded in bearing with a hardened steel pin through  $\frac{1}{4}$  in. diameter holes were made on varying width specimens by Frocht.<sup>8</sup> In specimens loaded to ultimate in 10 min. the ultimate load alone was determined, and failure in every case was in tension across the hole. It was found that the ultimate bearing load increased from about 400 lb. at 0.50 in. width to 750 lb. at 1.00 in. width, then gradually fell off to about 650 lb. and remained almost constant with width up to 2.25 inches.

Ultimate bearing strength of polymethyl methacrylate was

<sup>4</sup> Engineering Report No. 1432, "Proposed Specification for Structural Thermosetting Plastics," Glenn L. Martin Co. (Apr. 1941).

<sup>5</sup> James Bond, "Bearing Strength of Plastics and Plywood," Trans. A.S.M.E. 65, 9-14 (Jan. 1943); MODERN PLASTICS 19, 70-73, 110 (July 1942).

<sup>6</sup> Meyer Fishbein, "Physical Properties of Synthetic Resin Materials," N.A.C.A. Technical Note No. 694 (March 1939).

<sup>7</sup> N. A. de Bruyne, "Plastic Materials for Aircraft Construction," J. Royal Aeronautical Society 41, 623 (July 1937).

<sup>8</sup> M. M. Frocht, "Photoelasticity," J. 329, New York (1941).

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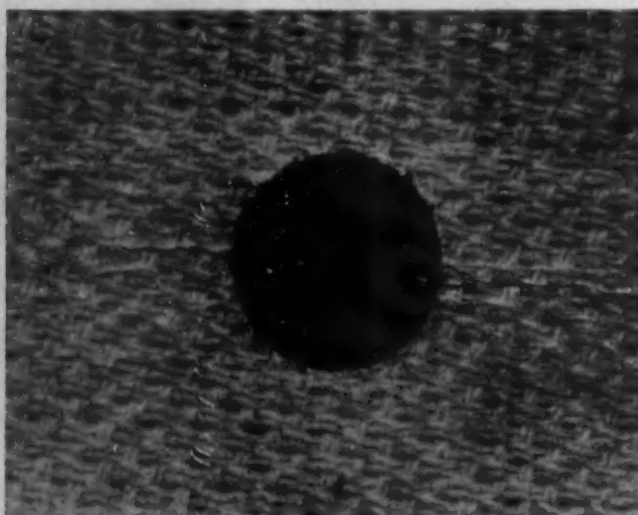
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EXTRUDED PLASTICS AND SPECIAL TOOLS

investigated in another laboratory.<sup>9</sup> It was found that: 1) substantially the same ultimate bearing stress was obtained for 1 or 2 in. width specimens, 2) ultimate bearing stress increased with increasing edge distance of hole up to  $\frac{3}{4}$  in. and then remained about constant, 3) ultimate bearing stress decreased with increasing thickness for the same diameter hole and with increasing diameter hole for the same thickness, 4) ultimate bearing stress was lowered considerably by polishing the bearing hole with either a polish or a solvent instead of reaming the holes, but there was found to be no difference between drilled or reamed holes, 5) the ultimate bearing stress of a  $\frac{1}{4}$  in. pin in a  $\frac{3}{8}$  in. hole (stress values computed on basis of  $\frac{1}{4}$  in. diameter) was not a great deal lower than in  $\frac{1}{4}$  in. holes.

The last-mentioned test was made because of the fact that if aluminum alloy or steel bolts or rivets are employed with thermoplastic material, the holes must be made considerably larger than the bolt or rivet since the coefficients of thermal expansion of these plastics are several times those of metals. However, the laminated thermosetting plastics have coefficients of expansion about the same as aluminum alloys. In the case of aluminum alloy rivets in phenolic laminates, oversize holes should not be required for the purpose of allowing for thermal expansion. The general subject of the effect

<sup>9</sup> "Physical Properties of Plexiglas, Pin-Load Bearing Strength," Rohm and Haas Co. Bulletin.



11



12

of oversize holes on the bearing properties was not investigated during these tests.

For parallel phenolic laminates, the bearing strength at 4 percent deformation and the ultimate bearing strength in the lengthwise direction are about comparable to the corresponding properties in the crosswise direction. This is also true of the yield and ultimate compressive strengths, whereas the tensile properties are considerably higher lengthwise than crosswise. In general, however, there does not appear to be any specific relation between the bearing properties and the tensile and compressive properties, as shown by the variation in the ratios given in Tables IV and V.

All the specimens except the impregnated, compressed laminated maple failed in tension across the hole. Tables II and III show the maximum load divided by the net tensile area—thickness times the quantity: width minus hole diameter. This stress compared to the tensile strength of the material may be used for qualitative comparison of the notch sensitivity of the materials and is in use by the British as a standard test which they term, "bolt-hole tensile strength." The results show that thermosetting plastics are much more notch sensitive in tension than are thermoplastic materials.

Some data on the bearing strength at 4 percent deformation of a few phenolic laminates at  $-70$ ,  $+76$  and  $+160^{\circ}$  F. are given in another article.<sup>10</sup> These show that the decrease in bearing strength with increasing temperature is of the same order of magnitude as the change in other mechanical properties which also decrease with temperature increase. The bearing strengths at  $160^{\circ}$  F. were about 65 to 80 percent of the room temperature values. Greater percentage decrease would be expected for thermoplastic materials since their other mechanical properties show greater percentage decrease than do those of the thermosetting plastics. The bearing strengths of thermoplastics at low temperatures are higher than at room temperature.

Because of stress concentration in bearing, the tensile failures at the ultimate, start at both sides of the hole. No visible crack occurs in most materials until immediately before failure; that is, the propagation of the crack is rapid. However, Fig. 11 shows a crack in a specimen of a fabric-base laminate for which the load was released just before the ultimate. For most materials, it is difficult to stop at this point before failure occurs. Figure 12 shows the deformed stressed area under the pin, in a transparent thermoplastic loaded to near the ultimate. Figure 13 shows typical fractured bearing specimens.

Most of the thermoplastic materials exhibited considerable bearing deformation before finally failing in tension. Except for the allyl glass-fabric laminate which deformed about  $\frac{1}{8}$  the diameter of the hole before failure in tension, the thermosetting laminates did not deform noticeably before failures.

### Summary and conclusions

The higher bearing strengths are exhibited by the various laminated thermosetting plastics; the bearing strengths of

<sup>10</sup> P. M. Field, "Basic Physical Properties of Laminates," MODERN PLASTICS 20, 91-102, 126, 128, 130 (Aug. 1943).

11—Bearing specimen showing crack occurring before fracture. As shown here, the loading direction was upward. This illustration shows the specimen magnified approximately  $4\frac{1}{2}$  times. 12—Bearing specimen showing deformed area. As shown in this photograph, the loading direction was upward. The specimen in this picture has been magnified approximately  $6\frac{3}{4}$  times

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the thermoplastic materials being considerably lower. High-strength paper phenolic laminate had the highest bearing strength of all the materials tested. Bearing strength at 4 percent deformation of the hole diameter for the standard specimen ranged from 4000 p.s.i. for a cellulose acetate butyrate material to 31,100 p.s.i. for cross-laminated high-strength paper phenolic laminate. No specific correlation was found between bearing strength and tensile or compressive strength. However, in general, the higher strength materials developed higher bearing strengths.

Ultimate bearing stresses are also reported. The failures at the ultimate for all specimens except compressed phenolic-resin-impregnated laminated maple were in tension across the hole. The specimens of the latter material failed in transverse tension by splitting lengthwise through the hole.

Some of the materials tested with  $\frac{1}{4}$ -in. pins failed in tension across the hole before 4 percent deformation was reached because of the notch sensitivity and brittleness of the materials. This would not occur in compressive-loading-type bearing tests. Retests in tension loading were made on some of these materials with  $\frac{1}{8}$ -in. diameter holes, and 4 percent deformation was obtained. In order to obtain data on all materials for comparative purposes under the same test conditions, the standard diameter hole should be 0.125 in. at an edge distance of 0.625 in., so that 4 percent deformation may be obtained even on brittle materials.

The limited data reported herein on the effect of hole diameter, edge distance and thickness indicated the following:

1. For both  $\frac{1}{8}$  in. thick fabric-base phenolic laminate and  $\frac{1}{8}$  in. thick cellulose acetate sheet, the bearing strengths determined with  $\frac{1}{8}$ - and  $\frac{1}{4}$ -in. pins were comparable if the same edge distance in inches was used. However, at the same edge distance ratio (edge distance divided by diameter) of 2.5 used for the  $\frac{1}{4}$  in. pin, lower values were obtained with the  $\frac{1}{8}$ -in. pin. This was not true of the ultimate bearing stress, which increased markedly with decrease in diameter.
2. For the same sheet thickness and hole diameter, both

bearing strength at 4 percent deformation and ultimate bearing stress decreased with decreasing edge distance.

3. Bearing strength and ultimate bearing stress were comparable for both  $\frac{1}{16}$  and  $\frac{1}{8}$  in. thick sheet using the same diameter pin and same edge distance. This was true for both Grade L fabric-base phenolic laminate and for cellulose acetate materials.

The use of these bearing data for design is limited to the particular conditions of diameter, thickness and edge distance investigated. It is emphasized that, in general, for design use the following variables should be considered for each plastic material: thickness, diameter of hole, edge distance, minimum allowable distance between holes, effect of temperature, the looseness of the pin in the hole, vibration, rate of loading and creep.

## Low-pressure molding

(Continued from page 112) the desired results, ingenious new techniques had to be developed and every known variety of molding technique had to be utilized. In addition, despite the fact that the only pressure necessary for lamination is that which will be sufficient to keep the material in intimate contact with the form, many problems such as drainage, tolerance control, etc., had to be solved.

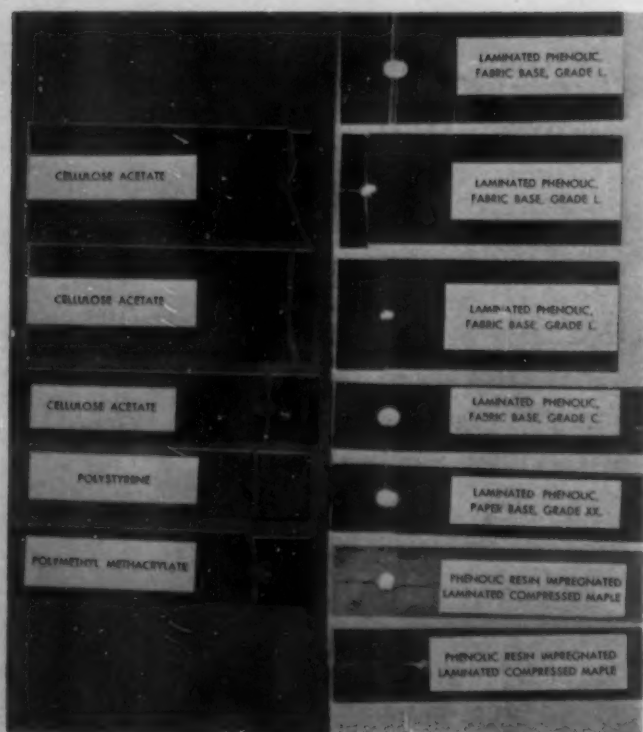
When selecting the forms to be used in contact methods, such factors as the ability of the form to transmit the heat necessary for polymerization of the resin should be given consideration. Plastic and wood forms can be used when the heat is transmitted from outside the laminate rather than from the interior. However, these materials should not be considered when it is necessary to produce many parts from the same mold. Consideration must be given to the fact that wood, plaster, *papier mâché* and similar non-metallic forms have a tendency to absorb resin to such an extent that the dimensional stability of the product may be impaired. In most cases where a substantial quantity of parts are involved, properly made metal tooling has proved most successful.

Techniques in the fabrication of compound shapes in contact resins may best be described by summarizing the fabrication of certain parts. Consider the case of a streamlined instrument housing to be fabricated of a cotton-base material. A female split metal mold is used. The fabric is cut into orange-peel shape and then laid into the cavity. A rubber-bag technique which involves the use of pressure to force the wetted fabric to conform to the cavity was used in this part. The diaphragms which prevent the air from going through into the fabric may be of rubber, neoprene, cellophane or any other film of such a nature that it will not adhere to the cured part. In determining what tooling will be necessary for a contact part, particular attention should be paid to the side of the mold against which the outside surface will be obtained.

In the case of a wheel fairing for the B-24 airplane, a metal fairing was employed as the mold. The fabric was draped over this fairing, and the entire unit was enclosed in a vacuum bag and inserted into the oven for cure. While this technique presents a very simple method of building one acceptable part, it is obviously not a production method because of the fragility of the metal fairing which served as a mold. Since the plastic part was built in the same manner as its metal counterpart, it did not utilize the properties of the plastic material to advantage. A redesign with these properties in mind is indicated.

(Please turn to next page)

13—Typical fractured bearing specimens



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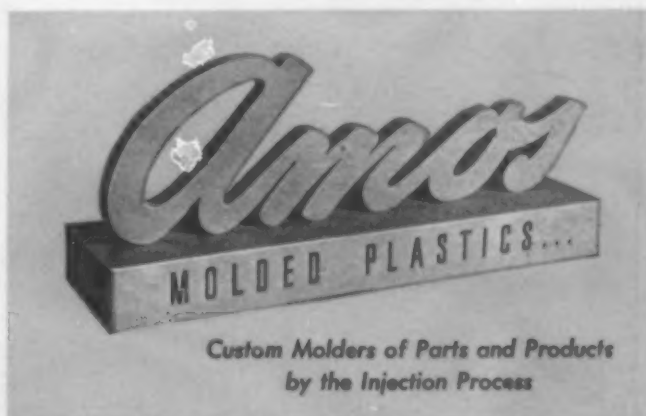
● Amos plastic product engineering and Amos injection molding have produced this new type medicinal atomizer. It's a germ-gun that shoots a measured dose—using every drop of a predetermined amount of antiseptic or medicinal spray. The plastic material is *Saran*—inert to chemicals. And there are the customary molded plastic advantages, such as—adequate strength with light weight, economy of manufacture and rapid production. This is but another example of the many reasons product engineers are redesigning parts and products for molded plastics.

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In the case of a life-raft door, construction involved the cementing together of a skin and a hat section to form the integral part. The skin section was a flat laminate made in the usual flat laminate method, which consists of laying out the wetted fabric and curing, using no pressure whatsoever. The hat section, however, was made by draping the wetted fabric over a male mold contoured to the inside of the hat section. This part was then inserted in a vacuum bag and cured. Finally, the finished pieces were cemented together.

A male and female mold should be used only as a last resort. This conclusion is based upon the fact that, while good results can be expected from a well-built mold, such a mold is expensive and requires precision layout of materials and a predetermined mold capacity if the percentage of resin content is not to be affected. In contrast, in a bag technique wherein one side of the mold is a flexible member and receives a uniform fluid pressure, irregularities in layout and resin content are automatically controlled.

The least appreciated and most difficult job which must be done in order to make a permanent place for low-pressure plastics in the industry is the tedious and expensive experimental and educational work. Extensive tests and experimental programs are being carried on with the Army, the Navy and the aircraft industry. Slowly but surely, engineers and designers who have always thought in terms of metal are beginning to think and design parts for low-pressure plastics. Only the early stage of development has been covered. The job is great and the interest lively. Our pioneering efforts must be augmented by the full support of all forward-looking members of the industry. The entire field of plastic reinforcements should be re-examined. Manufacturers of such material should be awakened to the need of research for new fillers and should be shown the tremendous possibility for their uses. Trial and error has indicated some of the general applications for low-pressure plastics.

When initial small quantities are needed and it is desired to eliminate the expensive tooling required for metal parts, the proper low-pressure plastic can do the job. A good illustration of this application is the cabin and nose assembly of one type of small aircraft. The entire cabin and nose sections were made in a short time from a plaster mock-up. Doors, panels, framework, etc., were made from glass fibers impregnated with low-pressure plastic. The immediate obstacle of expensive tooling was eliminated, and the plastic cabin demonstrated such outstanding advantages in design,

### 3—Low pressure molding was used for this wheel fairing

PHOTO, COURTESY SWEDLOW AEROPLASTIC CORP.



in weight and in sound insulation that the production order for this craft now specifies low-pressure plastics.

When weight-saving is a factor, as in the case of flooring in aircraft and other parts where the needed physical properties are present in the plastic, the application of this medium is proper. It is also indicated when man-hour savings can be established to a degree where the finished part is not so costly as the metal part although the per pound price of the raw material may be more than that of metal. In aircraft, low-pressure laminates can definitely show a man-hour and price-saving advantage. This is because the contoured metal shapes used in planes generally begin with flat metal sheets and require the forming of several parts with expensive dies by drop hammer or hydro press, followed by manual assembly of these parts. Other examples of the saving of man-hours and cost are ducts and such items as the air scoop (Fig. 2). Low-pressure plastics are best applied where they do a better functional job than any other known material. With the proper combination of filler and low-pressure plastic, electrical properties are obtained which cannot be had from other mediums. Other examples of low-pressure jobs are fuel tanks and fuel-cell liners which protect the self-sealing gas tanks in a manner not equaled by parts made of any other material.

The following list of some of the items manufactured by our company further illustrates possible applications of low-pressure material:

Access covers	Life-raft doors
Air ducts	Lockers
Air scoops	Pitot tubes
Ammunition boxes	Quadrant stand
Ammunition hoppers	Pyrotechnic tubes
Antenna masts	Rotor-blade assemblies
Anti-icer tanks	Spinners
Baggage doors	Stabilizer fairings
Battery access doors	Stabilizer fillets
Battery strongbacks	Stabilizer tabs
Bulkhead assemblies	Tail cones
Cabin assemblies	Tail-gun turrets
Camera doors	Torpedo-camera installations
Dorsal fillets	Valve housing
Flaps	Vertical stabilizers
Floats	Water tanks
Fuel-cell guards	Wheel fairings
Fuel-cell liners	Windshield assemblies
Fuel-cell tanks	Wing-loading edge assemblies
Gunner's door	Wing panels (under)
Instrument housings	"Y" assembly defrosters

Looking ahead at the wide range of postwar applications, the prospect is indeed encouraging. Those engaged in the transportation field—aircraft, trains, buses, trailers, etc.—are seeking light weight and strength. They are also interested in easily and economically producing new models and designs and thus keeping abreast of the times. In the building industry there are possibilities for the use of low-pressure plastics in the prefabrication field. The ease of adapting these plastics to interiors, exteriors, packaged bathrooms and kitchens is no idle dream.

There can be no question that the low-pressure plastics are here to stay. The question is: Will people in the industry have the imagination, the initiative, the courage and the application to do the necessary pioneering and work out the proper applications?

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Synflex Compounds as developed in our own laboratories are produced only in the form of rods, tubes, shapes, tapes and elastics. These distinguished materials meet and surpass the most exacting requirements of the electrical and aviation industries. Many formulations are available, each for a specific job.

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INDUSTRIAL SYNTHETICS CORPORATION  
60 WOOLSEY STREET, IRVINGTON, NEW JERSEY

# Water absorption

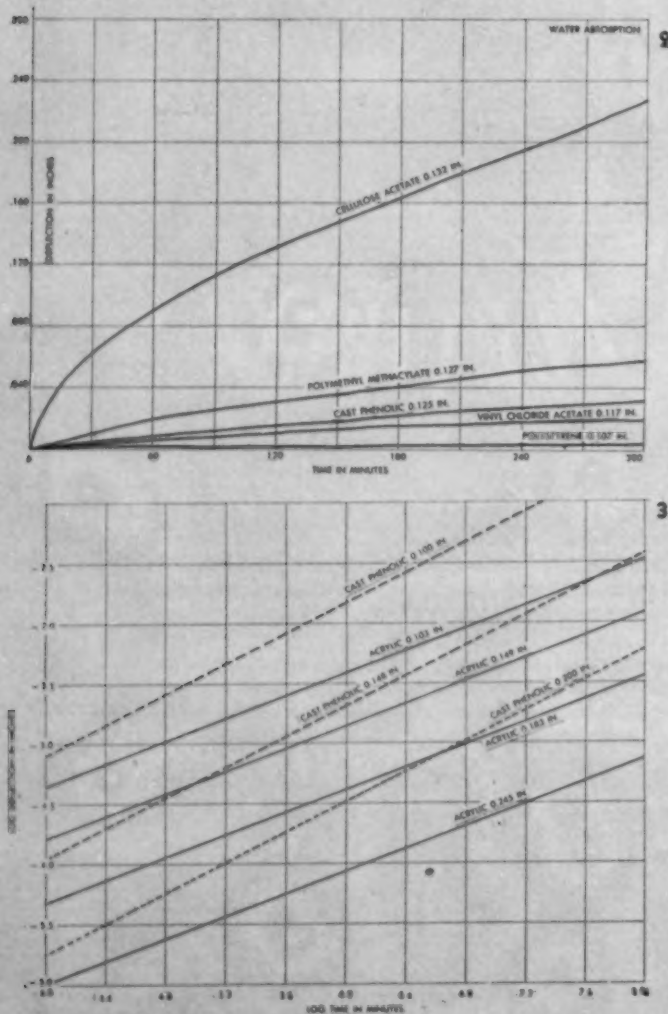
(Continued from page 138) the samples tested, but the same measuring technique was used in all cases to obtain comparative data.

## Results

The deflection versus time characteristics of various plastics are illustrated in Figs. 1 and 2. These results, obtained within the space of a few hours, clearly indicate how the water-absorption and swelling characteristics of various plastics differ from one another. The slopes of the curves are comparable to long-time water absorption tests evaluated by other methods. If the measurement of beam deflection is extended over a period of days, it is found that a maximum deflection is attained, followed by a gradual return which theoretically should reach the original starting point when full water saturation of the plastic occurs. Of course prior conditioning of the plastic exerts a decided influence on the slope of the curves. The results reported herein were obtained on specimens 5 in. long and 0.5 in. wide, conditioned in an oven at 125° F. to a dry state.

Data for acrylic and cast phenolic plastics of different thicknesses are plotted in Fig. 3. It appears that a constant slope will be obtained for a given material when the log of

2—These curves show deflection as a function of time for various plastics. 3—Log deflection—log time plots of polymethyl methacrylate and cast phenolic plastics of various thicknesses



deflection is plotted against the log of time. Nevertheless, the position of the curve is determined by the specimen thickness.

Determination of water absorption by the beam deflection method appears to be a very useful technique for evaluating water absorption characteristics in a short period of time. The method is much more sensitive than other prevailing methods, and results are readily reproduced when the equipment has been properly set up. It has the additional merit of measuring dimensional changes which reflect the problems of practical application of plastics. The same technique has been applied to measuring moisture effects upon wood laminates,<sup>3</sup> and it can also be employed in determining the effects upon plastics of liquids other than water.

<sup>3</sup>"Creep in Aircraft Plywood," by J. Delmonte and B. Watkins, *Aero Digest* 43, 306-7, 365 (July 1943).

## Three newcomers

(Continued from page 123) for long periods of time. Comparatively low injection pressures are needed—in this application approximately 4000 p.s.i. are used. Out of the complete 80 sec. molding cycle, 30 sec. are needed to chill the part completely, while the balance of the elapsed time is taken up in opening and closing the mold and injecting the material. Another interesting feature of this new material is its very low cold-mold to cold-piece shrinkage. According to the molders, the diameter of the 18<sup>1</sup>/<sub>4</sub> in. piece measures only 0.020 less than the diameter of the mold—indicating a shrinkage of only 0.001 per inch.

The successful solution of the threefold, interrelated problem involved in the molding of this emergency escape panel may well spell the difference between life and death for crews trapped below deck by jammed doors when a torpedo strikes or when fire or explosion occurs. When these plastic pieces are installed, one quick kick provides an opening free from splinters and jagged edges.

Credits—Material: Formula No. 110, Plastics Veneering, Inc. Molded by Phoenix Products Co.

## Marking methacrylate

(Continued from page 113) a relatively short time. High pressures must be used in conjunction with hard carborundum grits.

### Embossing

Where only a simple design or lettering is to be marked on the plastic surface, an inexpensive steel or brass die may be used. If the letters are not too broad in stroke, no heat need be applied to the die. Almost any engraver can make the dies for this work and set them up in a simple jig which provides the leverage necessary to emboss the methacrylate surface. It is also possible to punch-stamp small areas of this material but, in general, hand or bench leverage jigs are preferable. If a curved surface is to be marked, both the die and the backing block should be shaped to the same radius as the part.

In a modification of this arrangement the die is heated with results similar to those shown in Fig. 1. It is also



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Successfully producing non-ferrous metal and steel "prop" blades to withstand a 70-ton pull at high speeds means intensively double-checking for fatigue stresses which "pop" up occasionally and eliminating this threat of failure before it actually happens in combat.

A McAleer *tailored-to-the-job* greaseless type composition and finishing method helped solve the problem. Not only were the occasionally microscopic fatigue stresses revealed, but the

unbelievably smooth finish obtained, made it possible to feather the "prop" blades with practically no coefficient of air friction at high speeds.

McAleer Finishing Engineers were ready for this assignment. Long before the urgency of national peril, McAleer was busy helping aircraft engine manufacturers obtain a similar type finish on operating parts of the power plants that actually drive these propellers.

Pass YOUR hard-to-solve finishing production problems on to McAleer. Our broad experience in production finishing procedure and product improvement through finishing, can help you materially in meeting your war production finishing contracts.

Be the material, metal, plastic or wood—if the job can be finished better, faster, more economically, McAleer "know-how" will find the way.

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possible when employing this method to insert gold or black leaf between the die and plastic so that the marking will be clearly indicated in color (Fig. 1). Marking ink also may be spread over the die surface before the embossing operation takes place. This marking, or "branding" as it is sometimes called, may be applied to either the front or the back surface of transparent material.

The methacrylate surface may also be embossed with a cold die after the material has been heated to 200 to 300° F. With this method a certain amount of material is actually swaged out of position and into the design of the die. In constructing these dies, space must be allowed into which the displaced plastic can flow.

### Etching

Some work has been done on methods for etching methacrylate. One process is based on an etching solution consisting of either ethyl alcohol or acetone mixed with water which, particularly when heated, softens the plastic surface and causes it to become white. Paper adhesive tape may be used for masking the methacrylate, and the desired design executed by cutting this tape into a stencil. After the solution has been applied to the plastic by immersion or printing, an etched effect similar to sandblasting can be obtained. This etched appearance can be heightened if a white pigment is incorporated in the solution which is then applied in such a way that the pigment adheres to the etched area (Fig. 2).

Other methods have been developed by individual manufacturers who offer an etching service to the plastics industry. It is probable that each of these processors has devised his own etching solution and masking materials which are considered trade secrets.

### Printing

The tendency of methacrylate sheets to vary as much as 10 percent in thickness from sheet to sheet and within a given sheet increases the difficulty of printing on this material. One successful method involves the use of rubber printing

plates. The compressibility of these plates helps to compensate for thickness variations in the plastic sheet. It is also possible to put the methacrylate parts through the press several times, each time with a heavier impression until the low spots are printed. Methacrylate is not flexible enough to be printed on a cylinder press; only a platen press is satisfactory.

In addition, there are plastics marking machines which operate on a principle comparable to offset printing. The lettering and other markings are first printed on a rubber roller, then transferred from the roller to the methacrylate sheet. In some models the rubber roller is removable so that it can be carried to a particularly large fabricated part. Manufacturers have developed several printing inks for use with this equipment. These inks incorporate a plastic solvent, thus providing durability.

### Silk screening

Silk screen reproduction methods have been found to be very satisfactory for the marking of flat and formed methacrylate. Recent improvements in this type of marking have broadened the scope and improved the quality of this type of work. The screen can be made to fit practically any shape, and the paint can be applied to the surface and air dried or baked (at temperatures below 125° F.) to secure the proper adhesion and durability. Either the photographic method or a lacquer stencil method can be employed in the manufacture of the screens themselves. It is also possible to use the cellulose nitrate cut stencil on a wire mesh screen. The type of screen depends upon the amount of detail that is required for the marking. Standard silk screening practice is followed in this work except for the fact that specially formulated inks are necessary. These inks are available in opaque, semi-opaque and transparent colors.

### Photographic methods

For accurate reproduction of fine detail, photographic methods are recommended. In one technique, the photo-

1—The small nameplate in the foreground was pantographically engraved on the translucent material with black pigment wiped in to increase legibility. The lettering on the square of methacrylate at the extreme left was printed. The transparent sheet in the center background was engraved with the miscellaneous lettering. Embossing with a heated die was employed in the case of the small square at the extreme right. In the case of the lettering at the top of this piece of methacrylate, black leaf was interposed between the material and the die. 2—In etching the transparent desk plate, a white pigment was incorporated in the etching solution. To increase legibility, black pigment was mixed with the solution prior to the etching of the translucent nameplate



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*Floating* LAMP

MOVES FREELY IN ANY DIRECTION

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sensitive film is obtained from the film stock supplied for photo-engraving and offset printing. The gelatin film must be stripped from the acetate base and cemented to the surface of the methacrylate sheet. Needless to say, this operation must be carried out in a photographic dark room. A negative of the required marking is then made, and a contact print projected onto the plastic. Since methacrylate is unaffected by photographic solutions, the plastic print can be put through the standard developing processes. Several firms offer a photographic marking service to the industry.

### Delcomanias

Where a considerable amount of lettering is to be marked on a given part, decalcomanias have been found to be practical and economical. The color possibilities are practically unlimited, and the adhesion to the plastic is good.

### Temporary marking

If the marking is of only a temporary nature grease crayon, commonly called china marking crayon, is recommended. It is also possible to mark methacrylate with ordinary ink which can be wiped or washed off. However, long drying periods are usually necessary when this method is used.

A very light sandblasting of the plastic surface is another way of achieving a temporary marking of the part in question. While this sandblasting need not be enough to offer serious interference with light transmission, it will provide a "tooth" for marking with ordinary lead pencil.

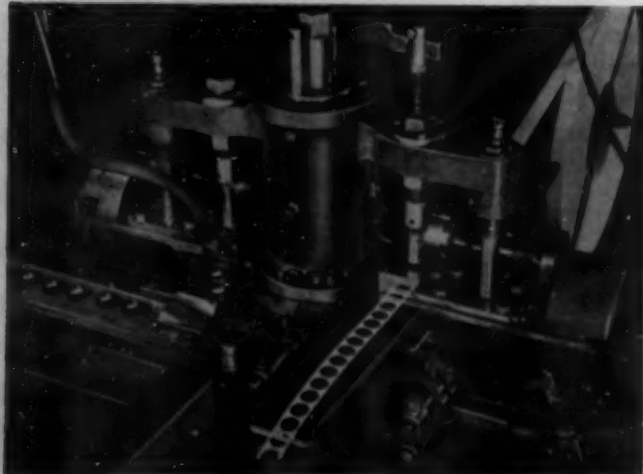
## New urea formula

(Continued from page 117) resistance to surface attack.

The stripping grade of urea differs from standard urea materials in that it has sufficient elasticity at the moment the mold is opened to permit its being instantly stripped, instead of unscrewed, from the threaded portion of the cap mold.

6—In this automatic lining machine the roll of lining material, which is in ribbon form, is mounted on a spindle (right background). This ribbon passes under an automatic die wheel that punches out round liners and forces them into position inside the caps which are delivered to the rotating star wheel from a moving belt. A hopper automatically places each cap in an upright position on the moving belt while the star wheel assures the correct spacing between the caps

PHOTO, COUNTRY ANCHOR HOEKLINE BLANK CORP.



In spite of this flexibility, finished moldings have the same permanent hardness of standard thermosetting compounds.

On the well-rounded threads used on closures, stripping urea can be successfully stripped on sizes of 15 mm. and over. Smaller caps have so great a thread depth in proportion to their diameter that the danger of splitting must be considered. Some molders use wax to aid in stripping phenolic materials but such an added lubricant is not necessary when running the stripping urea compound. In fact, a lubricant is deleterious, since it causes staining and the shearing of threads.

Stripping urea is available in the same range of colors as standard urea formulations, and it may be used in standard flat-bed or automatic stripping-type presses. The chart (Fig. 5) shows the cure and temperature relationships of stripping compounds. The shaded area indicates the length of time during which the compounds remain sufficiently plastic for the stripping operation. Data contained in this chart were worked out on the basis of a 23 mm. cap. The shaded area will vary, depending on the size of the cap—the larger the cap, the larger the range or shaded area.

## Washington round-up

(Continued from page 172) Regulation No. 6 Individuals may also petition for amendments to the order, and any such petition would have force if it came through the Industry Advisory Committee.

### Increased facilities for phthalic anhydride

The following news release, issued by WPB, should be of interest to plastics producers: Newly developed military demands have made it necessary to increase the nation's capacity for producing phthalic anhydride by between 12,000,000 and 15,000,000 lb. a year.

While the chemical is widely used in resins, dyes, plasticizers, certain food and pharmaceuticals, it is the effectiveness of one of its derivatives as an insecticide that has resulted in the increased military demand. This increased demand is expected to run to 24,500,000 lb. for this purpose alone. As a result, WPB officials said, allocations for other purposes—military as well as civilian—have been cut down to a "skin-and-bone" basis.

### Fenlin leaves the navy

Jack Fenlin, who has supervised the Plastics Section in the Navy Dept. for the past 2 years, has resigned to accept a position with the Daystrom Corp., Olean, N. Y. He will be manager of the Special Products Div. and will supervise the development and manufacture of new products. Before organizing the Navy Plastics Section in April 1942, Mr. Fenlin spent 13 yr. with Bakelite Corp. He will continue in a consultant capacity to the Navy.

### Restrictions lifted on plastic collapsible tubes

Collapsible tubes made exclusively of plastic, with or without the addition of a steel fastener at the bottom of the tube, are specifically exempt from regulations affecting other collapsible tubes, according to a recent announcement of the WPB. Before this amendment, plastic collapsible tubes were theoretically barred from production. WPB officials in the Container Div. never intended to prohibit the use of plastic collapsible tubes and enacted this amendment to clarify the order. Most plastic tubes were made of acetate, and served as containers for medical goods. Up to date, they have not been entirely successful due to water absorption. Container Div. officials are desirous that the experiments continue, and wrote this amendment to prevent interference with research now under way. But, of course, any plastic material used for this purpose must run the allocation gantlet before it will be made available.

NUMBER 11 IN A SERIES OF EDUCATIONAL  
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# ELIMINATING FLASH

The heavy flash, usually found around larger pieces molded by the straight compression process, is eliminated (or very greatly reduced) in TRANSFER MOLDING.

Flash is reduced because the mold is closed before the material is TRANSFERRED into the cavity and also be-

cause the TRANSFER process utilizes the flowing characteristics of thermosetting materials in their plastic state.

This contrasts with the employment of straight heat and pressure on molding powders or preforms packed tight into molds in the standard compression process. TRANSFER MOLDING achieves complete filling of the mold cavity with a minimum of material wastage.

The resin and filler are flowed into every small crevice of the mold, enabling the molder to turn out precise moldings with extremely thin or extremely heavy sections and practically no flash.

Eliminating flash saves not only material but considerable finishing cost as well. These are two reasons why more molders are turning to TRANSFER MOLDING for the solution of their production problems.

## TRANSFER MOLDING is the best way to

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  - Mold high-impact materials
  - Mold unsupported cores
  - Achieve maximum dimensional accuracy
  - Reduce trapped gases
  - Lower mold costs
  - Lengthen mold life
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  - Save material by eliminating flash
  - Get practical solution to difficult molding problems
- on thermosetting plastics.

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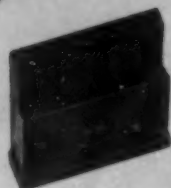
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SMALL DIA.  
MULTIPLE  
CORE PIN  
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We have the set-up and  
experience to give you the  
best in plastics molding of  
small and large parts, in  
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or complicated.

Compression and Transfer  
Molding of Thermosetting  
Materials Is Our Specialty

**PLASTIMOLD, INC.**  
ATTLEBORO, MASS.

## News of the industry

(Continued from page 176)

★ THE APPOINTMENT OF PATRICK B. ZAZZARA AS general manager of Molded Products Co., Chicago, Ill., was announced by D. R. Siragusa, president. Associated with Lionel Corp. for the past 25 years as assistant superintendent, Mr. Zazzara has had wide experience in the compression and injection molding of plastics, die-castings and work with screw machines. His time will be devoted to increasing the mechanical and operating efficiency of all molding equipment and supervising the production of Molded Products Co.

★ KOLD-HOLD MFG. CO., LANSING, MICH., ANNOUNCES the appointment of H. W. Whitmore to the position of chief engineer, succeeding R. H. Swart. Mr. Whitmore comes to this firm after 2 years with Automatic Products Co. and 10 years with General Refrigeration Div., Yates American Machine Co.

## New machine

(Continued from page 165) manner that the material injected into the die cavities is just below the curing or setting temperature. Heat from resistance-type electric heaters placed within and about the die is applied to offset heat loss, thus maintaining the die at the curing temperature.

In order to prevent the material from setting up in the injection nozzle, water flows continuously through the two heating electrodes, so that the material is chilled below the curing or setting point immediately after the heating current has ceased to flow. A transformer similar to one used for electric welding and controlled by electric timing equipment furnishes the power.

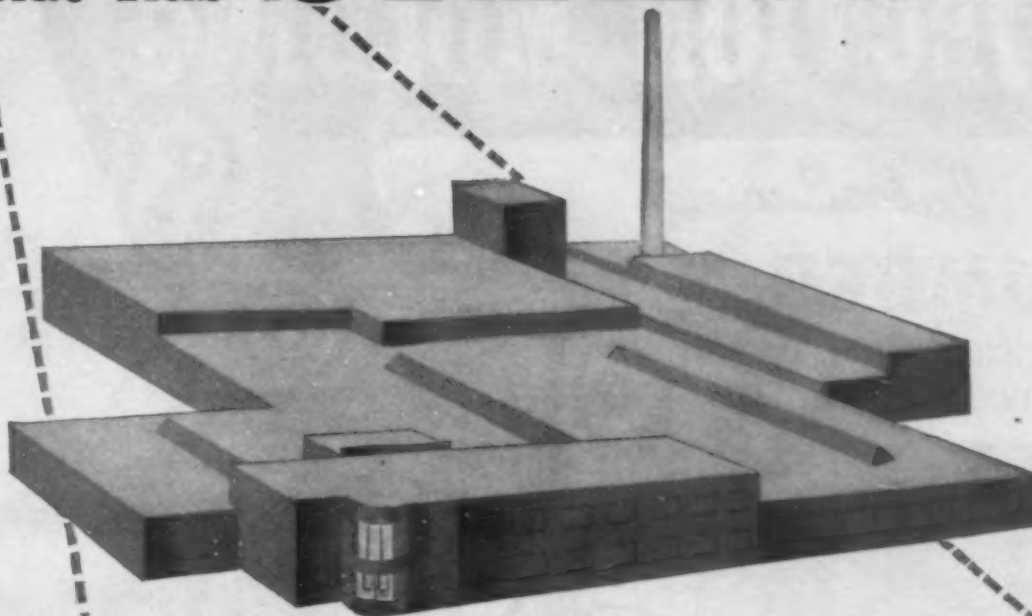
The jet molding process is also applicable to the injection molding of either soft or hard rubber articles. This method obviously cuts heating time as compared with ordinary compression molding, since the material is virtually up to curing temperature upon its introduction into the die. Here again, the time consumed is from one-third to one-fifth that required for compression molding, depending upon the thickness and weight of sections. A license for the use of the jet molding system embodied in this machine must be obtained from Plastic Processes, Inc.

The machine embodies the following features of engineering and construction: The functioning parts are built into a heavy beam frame of "moly" cast steel, with the beams and end castings in the form of a closed "U," providing a rigid die-clamping structure of 400 tons. The movable die plate, 21 × 25 in., moves within this frame by means of V slides working in hardened V-grooved inserts. The die platen is, of course, free of bars or other interference, so that its maximum area can be used.

The patented Lester hydraulically operated double toggle and link mechanism for holding the dies closed, operates vertically beneath the bottom or movable die plate, developing a die-locking pressure of 400 tons. It is built so that the "shock" load of injection is not applied directly to the toggle pins, causing possible breakage, but is transmitted through the hardened cam locks directly into the "U" frame. Automatic oiling of the cams is accomplished by use of a felt pad wiper system. The pads need be saturated only two or three times a week.

Rapid and easy die adjustment is accomplished by a single hand crank actuating a worm which rotates a worm wheel. The wheel is made integral with a large diameter Acme thread screw located in the center of the movable die plate, thus assuring control support and permanent parallelism of the die plates. The base of the machine can be embedded in the floor to bring the die platens to waist height. Total weight is approximately 19,500 pounds. Other variations in design can be developed for specific needs in any or all of the three types of injection systems mentioned.

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*Note:* Even though our production facilities are at present devoted to the war effort, an important and time-consuming part of your postwar job can be done NOW. We can help you get your ideas on paper . . . engineering and designing done . . . so you're ready for mold-making. A CMPC Development Engineer, working with your designers and engineers, can do much to insure practical, economical moldability of your plastic part. Get the jump on competition. Ask for a CMPC Development Engineer today. There's no cost or obligation.

Plenty!

For, when the proper time comes, you'll find, in this modern 2½ acre plant, everything needed to produce your postwar, plastic molding job just as it should be produced . . . to insure complete satisfaction, maximum economy, and on-time delivery.

For example . . . you'll find here exactly the type and size of press your job demands. If it can best be produced by transfer molding . . . that's the way we'll handle it. But if injection or compression molding would be better . . . we'll do it that way for you.

If your job requires a 500 ton press for most economical production . . . it's here . . . several of them. If a larger or a smaller one would be more advantageous . . . there's a complete range of sizes, including just the right one.

And whether yours is a simple flash mold or one calling for split cavities and special fixtures . . . we're equipped to design and build it carefully, painstakingly, in one of the finest toolrooms in the industry.

That's the way it is at CMPC . . . through the complete cycle of designing, mold-making, molding, and finishing . . . whatever is needed to give you the best in plastic molding . . . you'll find it here. And back of it all lies twenty-five years of experience plus a nation-wide reputation for quality . . . for doing even the toughest jobs well.

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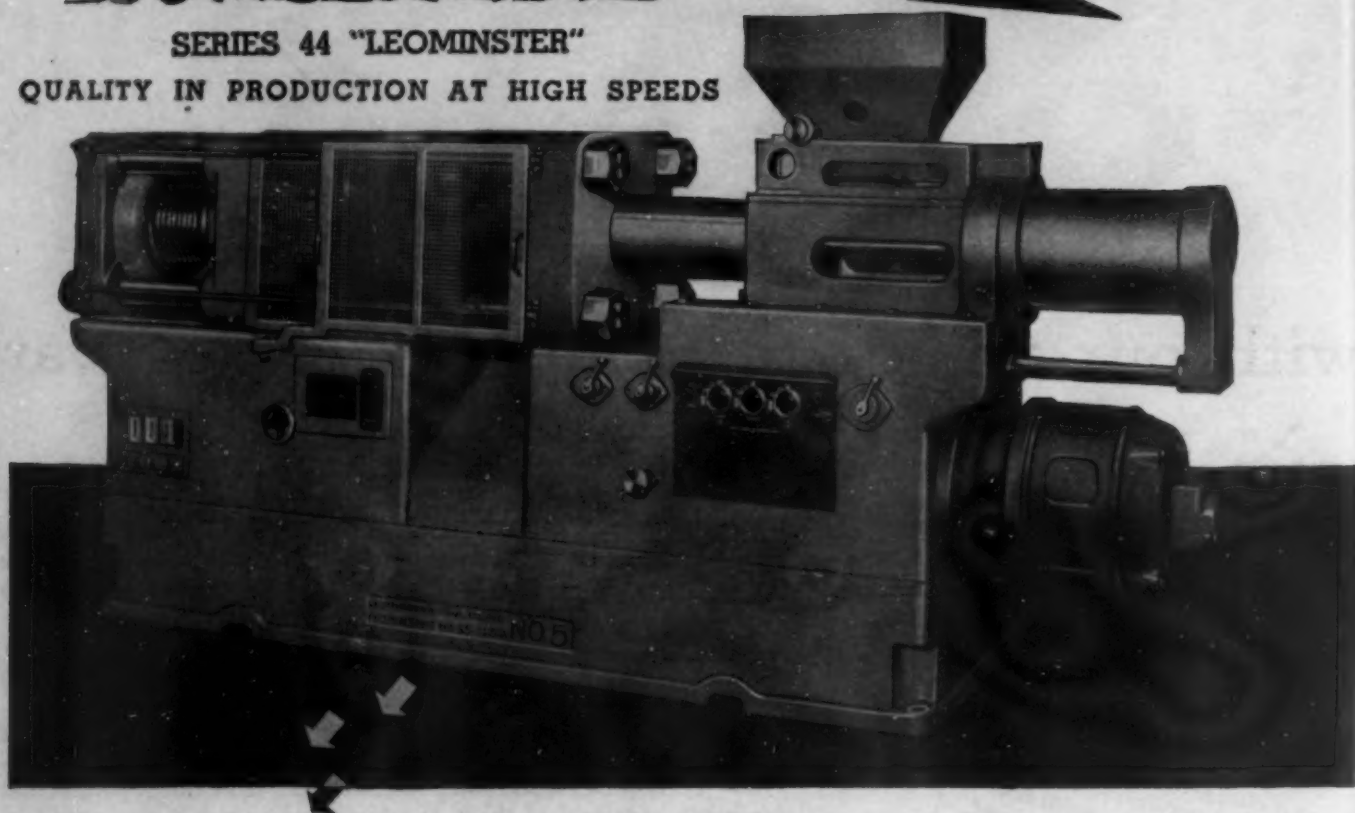
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This is our concentrated aim, today. While working at top speed for the war effort, our Valinite engineers are making every spare moment count by filling it with study of the possible problems of tomorrow's production and plans for their solution. We have but one desire — to even more thoroughly prepare Valinite for hundreds of peacetime applications. Already, this new low-pressure moulded reinforced plastic is meeting the rigid demands of war in scores of plastic structures. To business and industry, planning greater things after Victory, Valinite offers new versatility and efficiency as the new construction material of tomorrow.



Our ideas extend far beyond today's limitations. We are looking ahead and planning to do a better job in hundreds of new products for happier, more convenient living. The possibilities and advantages of war-born Valinite make it a material well worth investigating. Our Post-war Planning Bureau will be glad to discuss your problems with you at any time.



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AND  
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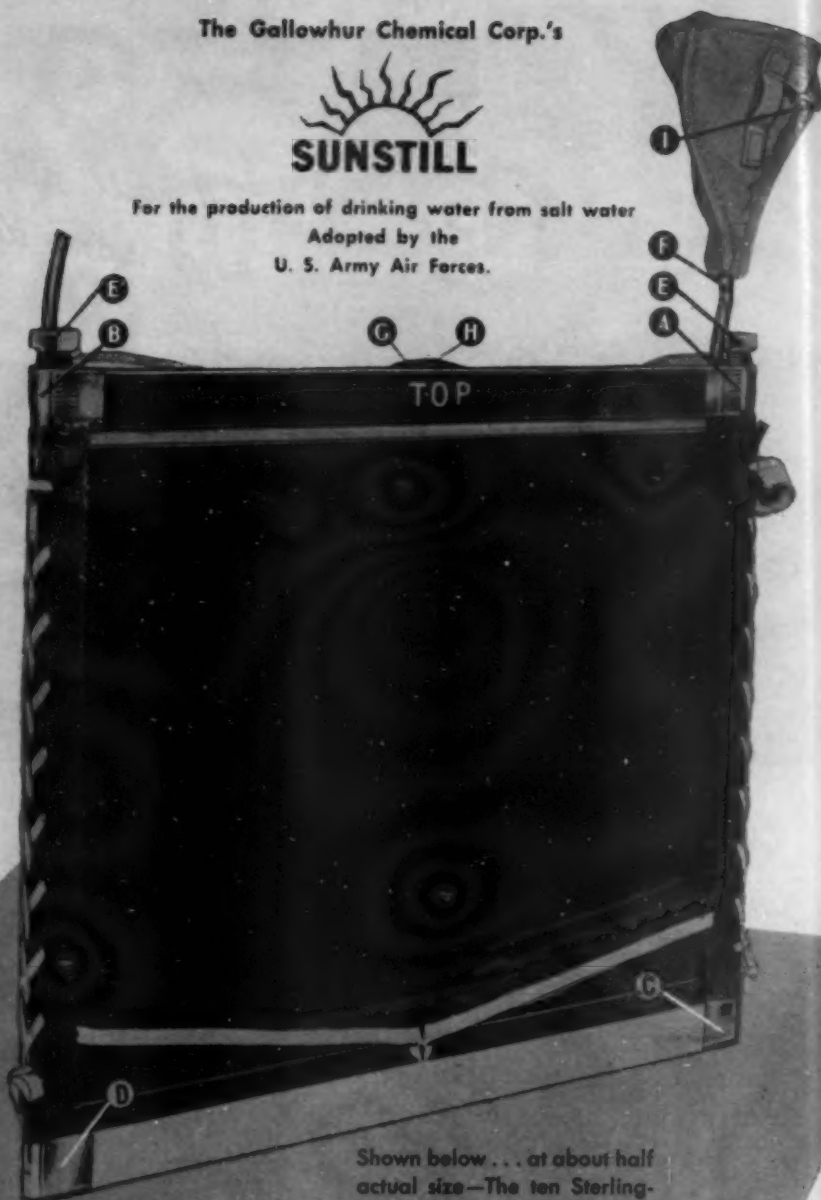
The Gallowhur Chemical Corp.'s



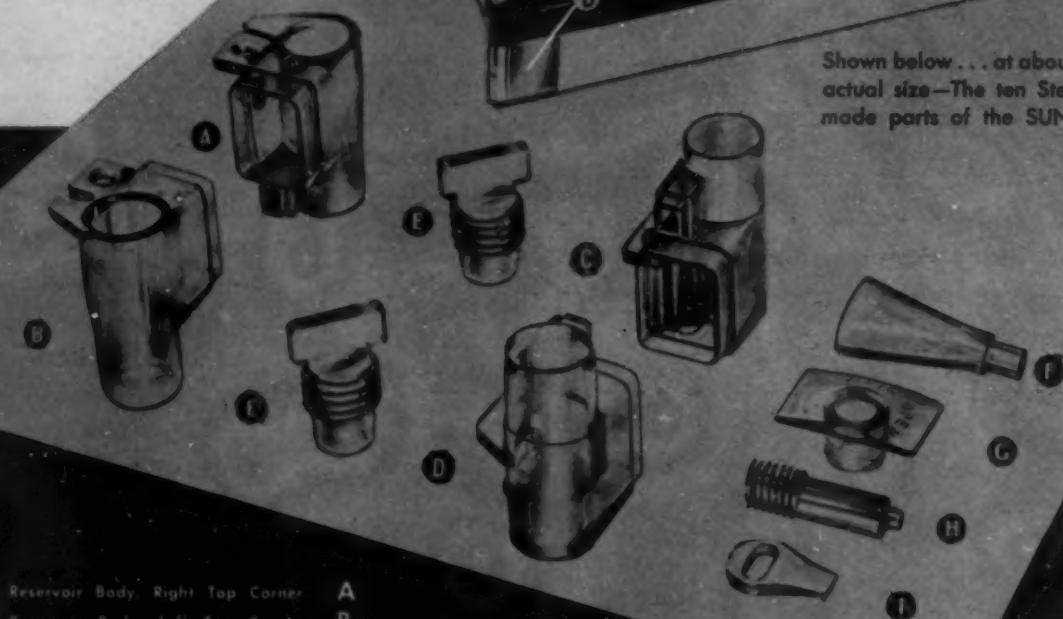
For the production of drinking water from salt water  
Adopted by the  
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FOR THIS EMERGENCY APPARATUS  
WERE INJECTION MOLDED  
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Four members of this parts family . . .  
A, B, C, D look enough alike to be quads  
—but each is a totally different structure,  
with differently sized and shaped open-  
ings branching off horizontally and verti-  
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and in several planes. Preparation was  
completed in comparatively short time.  
MATERIAL—Cellulose Acetate Butyrate  
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exacting. No machining re-  
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specs these ten parts  
exemplify Sterling  
quality at work!



Shown below . . . at about half  
actual size—The ten Sterling-  
made parts of the SUNSTILL



- Reservoir Body, Right Top Corner A
- Reservoir Body, Left Top Corner B
- Reservoir Body, Lower Right Corner C
- Reservoir Body, Lower Left Corner D
- Threaded Stiffener Rod Cap, Right E
- Threaded Stiffener Rod Cap, Left E'
- Scoop Connector Funnel F
- Valve Body G
- Valve Stem H
- Valve Stem Key I

**STERLING PLASTICS CO.**  
1140 COMMERCE AVENUE, UNION, N. J.

# Plastic Housings

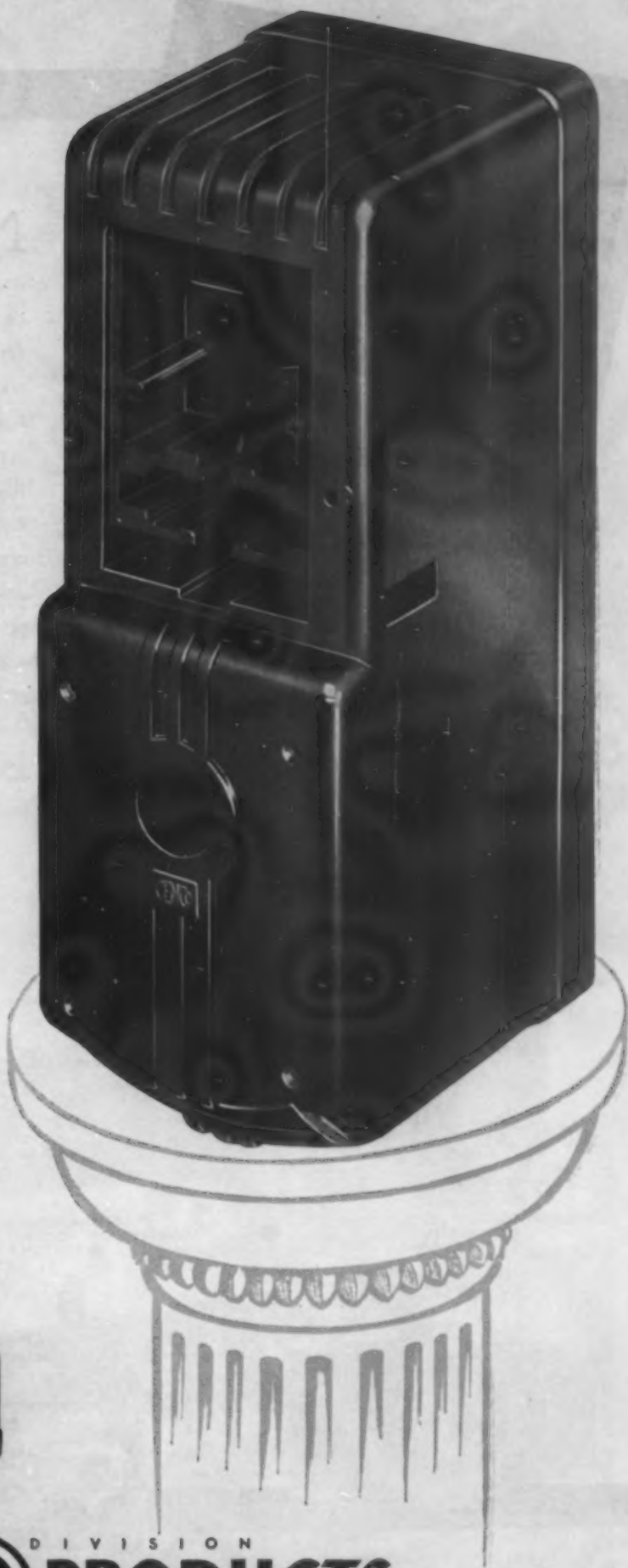
## MOLD DOWNRIGHT USEFULNESS INTO BEAUTIFUL EXTERIORS

Examine this sleek instrument housing. Notice the intricate design, with studs, bolt holes, dividers, and molded side holes. Every curve and angle serves a useful purpose. Yet in proportion, design and contour this housing is a thing of beauty. Even the louvers in the end wall add a decorative effect.

Only through the medium of molded plastics can beauty and utility be thus combined at practical cost. Yes, molded plastics can perform near-miracles . . . when guided by skillful engineering and production "know-how."

We, at MOLDED PRODUCTS, welcome assignments like this, which challenge our ingenuity. We take considerable pride in specializing on complicated housings. But we are also prepared to mold the simplest parts. Whatever your problem, ask one of our engineers to consult with you, or send us your specifications for quotation. MOLDED PRODUCTS COMPANY, 4533 W. Harrison St., Chicago (24) Ill.

Here is the completed "Photometer" produced by Central Scientific Co., Chicago. This instrument is used to make chemical analyses by accurately measuring the amount of light which will pass through the substance being tested.



PLASTICS DIVISION  
**MOLDED  PRODUCTS**

*Select  
your molding  
equipment  
from this*  
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No matter what plastic products you want to mold — what materials you want to use — you can get the right machine for any molding job from Watson-Stillman . . . builders of the most complete line of hydraulic equipment available for compression *and* injection molding on large scale production, diversified short runs or in the laboratory. All Watson-Stillman equipment embodies operating and production features consistent with latest trends in plastic materials and molding techniques. At Watson-Stillman you can also get—without obligation—unbiased

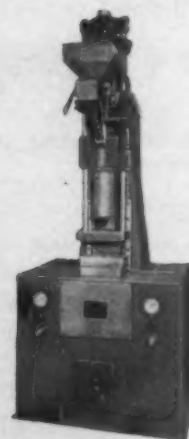
advice on selecting equipment and on other molding problems, based on intimate association with the Plastics Industry from its very beginning. Write or call the Watson-Stillman Company, Roselle, New Jersey.



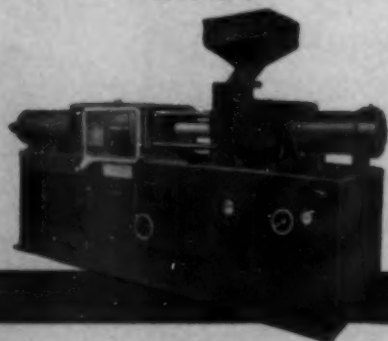
**AUTOMATIC COMPRESSION  
MOLDING MACHINES**  
25-75 TONS



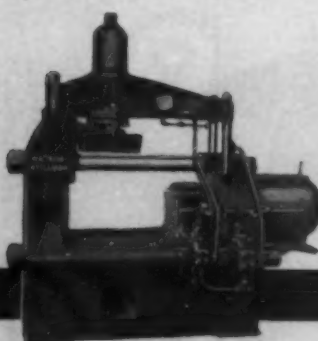
**SEMI-AUTOMATIC  
COMPRESSION MOLDING MACHINES**  
50-850 TONS



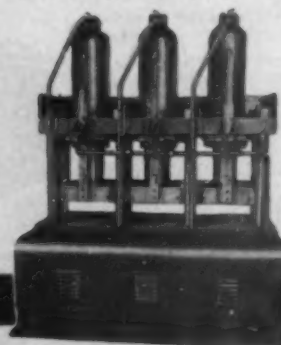
**VERTICAL INJECTION  
MOLDING MACHINES**  
2 AND 4 OZ. CAPACITIES



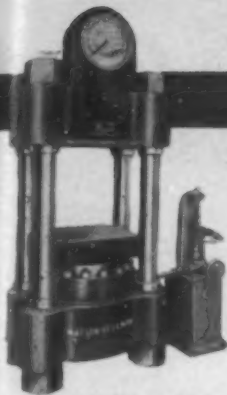
**HORIZONTAL INJECTION  
MOLDING MACHINES**  
6 TO 24 OZ. CAPACITIES



**ANGLE MOLDING  
PRESSES**



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75-TON, 3-UNIT



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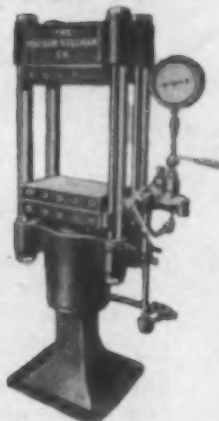
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20-200 TONS



GENERAL PURPOSE PRESSES  
FOR UTILITY MOLDING  
AND LABORATORY TESTING  
20-200 TONS



SEMI-AUTOMATIC  
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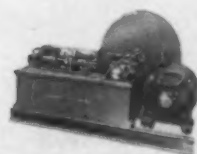
HINGED TOP  
RECORD PRESSES



HAND PUMPS



STEDIFLO PUMPS  
3-200 H. P.



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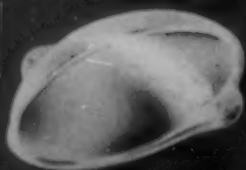
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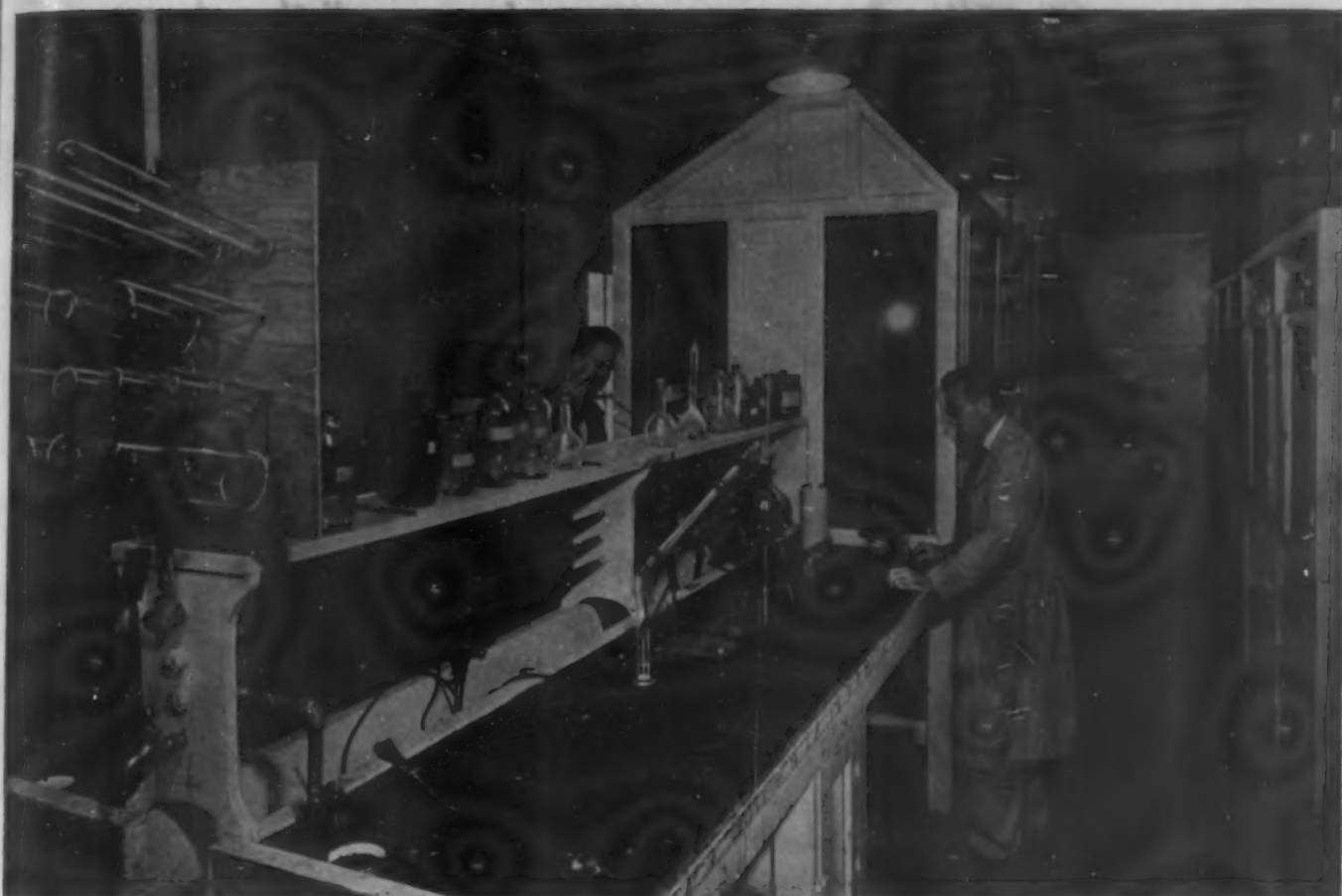
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see for yourself the advancements made in electronic preheating by

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# Tapping "Bugs"



— prove the simpler P-K Fastening Method is a short cut to stronger instrument assemblies

Industrial Timer Corporation, N. J., makes numerous timing devices widely used by the armed forces and by war plants. When planning the assembly of a newly designed Running Time Meter, they first tried machine screws for two "tricky" fastenings. The result was costly tapping delays and unsatisfactory holding power.

Familiar with the advantages of P-K Self-tapping Screws from use in metal assemblies, they called in a P-K Assembly Engineer. By following his suggestions, the bothersome "bugs" were eliminated, along with both the tapping operations.

Talk to a P-K Assembly Engineer about your fastening problems. He has specialized in all types of plastic and metal fastenings, and is well-prepared to show you how to save tapping time, prevent breakage, improve strength. He'll call at your request, — or, if you prefer, send assembly details for recommendations. Parker-Kalon Corp., 208 Varick St., New York 14, N. Y.

**PARKER-KALON**  
*Quality Controlled*  
**SELF-TAPPING SCREWS**

Give the Green Light to War Assemblies



**TOUGH JOB TILL TAPPING GETS GO-BY.** Fastening the plastic cover (A) to the plastic body was a tough job because a brass part lay between. When tapped for machine screws, brass chips fouled the plastic threads, holding power was poor. P-K Type "F" Screws eliminated both tapping and chip problem, assured a strong assembly.



**NO FIXTURES — NO FAILURES,** now that P-K Type "Z" Screws are used to fasten the brass dial plate (B) to the small hollow brass tubes that have been molded into the plastic case. With machine screws, a complicated fixture would have been necessary to hold the tubes for tapping, also tapping the tiny holes would have given constant trouble. Girls now drive the P-K Screws easily, without fixtures, into plain, untapped holes.

• P-K SCREWS ARE SOLD BY GOOD DISTRIBUTORS EVERYWHERE •



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The ninth in Aico's series of plastics applications.

## PLASTIC Shower Head for Ship or Shore

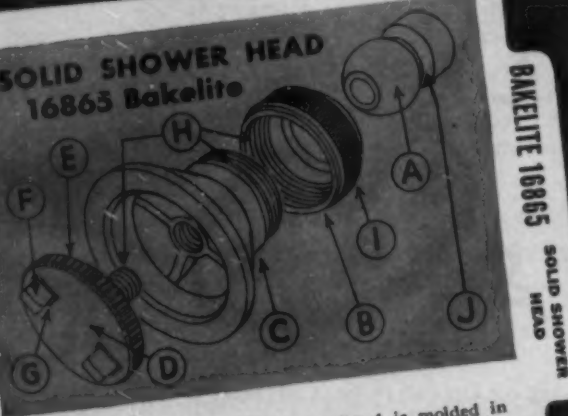


**THIS plastic Speakman Adjusta-Spray** shower head... redesigned in plastics for diversified Army and Navy duty... has important *functional advantages* over its

predecessor. Expensive machining and assembly operations involved in the previous method of manufacturing were eliminated. Result? *A 30% reduction in cost!*

Aico engineers, with more than 28 years of experience in plastics, were well equipped to adapt this part for plastics manufacture... to obtain best results from the material selected and to meet exacting government specifications.

### SOLID SHOWER HEAD 16865 Bakelite



#### PART DESIGN

This swivel type plastic shower head is molded in 4 parts—ball joint (A), ball joint retaining ring (B), shower shank (C) and shower face (D)—all designed and engineered to fit precisely when assembled. Grooves (E) on edge of shower face are slanted to produce a cross spray eliminating the possibility of a "dry center". Knobs (F) permit easy adjustment to regulate spray. Fillets (G) give added strength to knobs (F).

#### MOLD DESIGN

Threads (H) and knurled surface (I) are molded-in so that parts are ready for assembly when removed from mold. Extremely close tolerances had to be held to insure perfect mating of the parts. Multiple-cavity compression molds were designed for each of the four parts. The undercut (J) on side of ball joint is obtained by the use of splits.

#### MOLDING MATERIAL

16865 Bakelite—a thermosetting phenolic material—was selected for its high resistance to hot water and steam and low percentage of moisture absorption, a prime requisite in this fixture. This material is corrosion-resistant and affords the lustrous, permanent finish desired without a finishing operation. Its low shrinkage value is important in maintaining accuracy.

Write for copies of handy file cards, Nos. 1 to 9, as a reference for plastics applications.

# Aico

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MOLDING**

29th Year

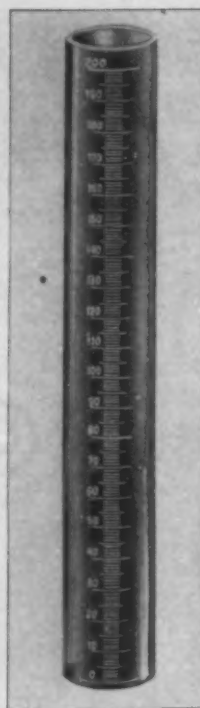
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## D-B NEWS

DILLON - BECK, IRVINGTON  
ENGINEERS • DESIGNERS • MOLDERS OF PLASTICS

## Calibrated Plastic Tube Modernizes Old-Style Rain Gages



IRVINGTON, N. J.

—Outmoded rain gages can now be readily modernized, thanks to the Dillon-Beck Manufacturing Company's recent introduction of a calibrated plastic inner cylinder which can be used in conjunction with the copper outer tube of the old-fashioned type gage.

Molded of clear Lucite, this new inside tube is quickly and easily readable. The calibrations, heat-branded on for permanency, indicate amount of rainfall up to 2" in fractions of 1/100th of an inch and accuracy of measurement is also heightened by the greater width of the mouth.

Valuable for general military use, the larger capacity of the tube is particularly important in climates where exceptionally heavy rainfall is the rule rather than the exception.

This new development was designed and produced by the Dillon-Beck concern and is a ramification of the D-B all-plastic rain gage used so successfully by the Army Signal Corps.

DILLON-BECK MANUFACTURING COMPANY  
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ENGINEERS • DESIGNERS • MOLDERS



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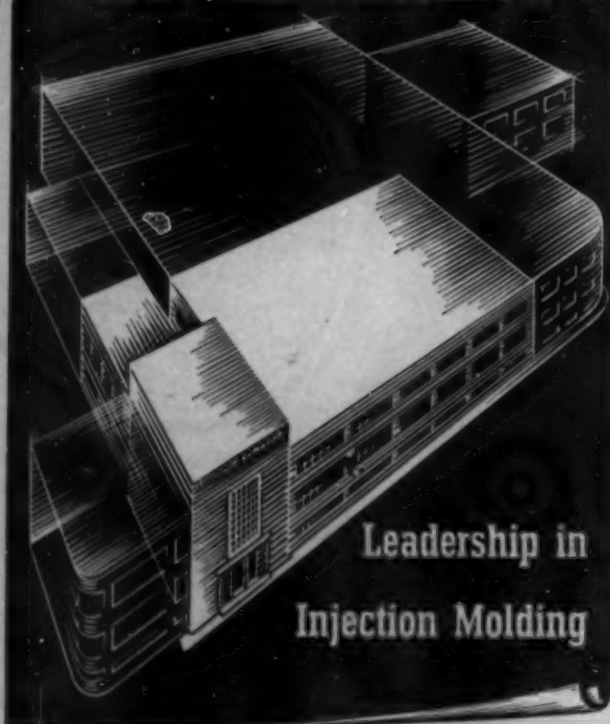
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Partial view of a Peerless automatic roll leaf hot stamping press in operation. Operator places article to be stamped on chain feed which carries it under the head of the press. Stamped articles are ejected automatically into a chute at the side of the press.

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It employs the most modern principles of reducing valve design. This valve is made by a concern that has specialized exclusively in regulating valves for nearly a half century, hence every detail is "just right." It is based on the latest knowledge of design and research. The body is of forged steel. Internal metal parts entirely of stainless steel. A formed packing of special material superior to leather is used which is immune to all fluids commonly used in hydraulic machinery. The pressure on the seat is balanced by a piston with the result that variations in high initial pressure have little effect on the reduced pressure.



For other ATLAS plastics plant products see the partial list in our ad in the January 1944 issue of MODERN PLASTICS.

**ATLAS VALVE COMPANY**  
REGULATING VALVES FOR EVERY SERVICE

277 South Street, Newark, N. J.  
Representatives in principal Cities

# Plastics SCRAP WILL HELP WIN THIS WAR

We specialize in the reworking of  
rejected molded parts  
obsolete molding powders  
or molding scrap  
into solid colors of a good molding powder  
in any desired flow

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**MANY OUTSTANDING FEATURES!**

Fully inclosed with  
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Detachable 75 pound  
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Heavy metal vibrator  
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Absorbers.

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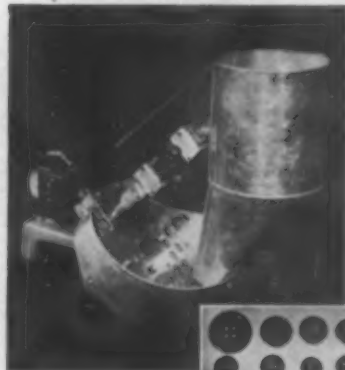
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**ELIMINATES  
MANPOWER  
PROBLEMS**



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Remove Moisture from Plastics Quickly  
and Cheaply with Nalco Infra-Red Lamps

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Learn all of the advantages of the Infra-  
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Exterior of Infra-Red Conveyor Belt  
Tunnel for removing moisture from  
plastic material prior to molding.



Sides dropped to show arrangement of  
Infra-Red light bank and materials  
passing under light conveyor belt.

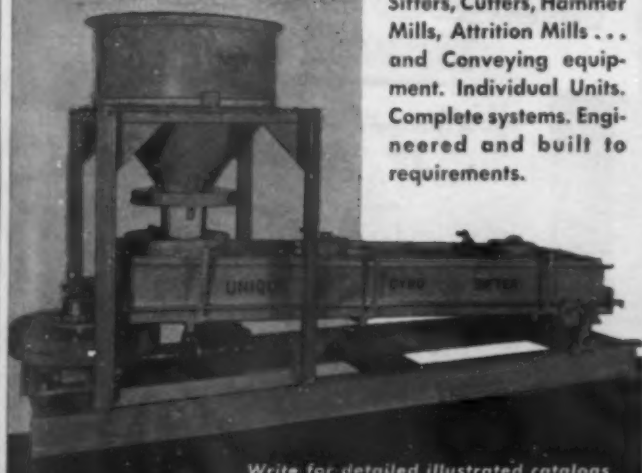
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Unique processing ma-  
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reclaims, plastic mate-  
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. . . comprises Mixers,  
Sifters, Cutters, Hammer  
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*with Speed, Safety and Efficiency*



Because these modern fastenings for plastics can be  
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"Thread-Forming" screws are used to fasten plastic  
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With complete  
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## Laminators and Molders

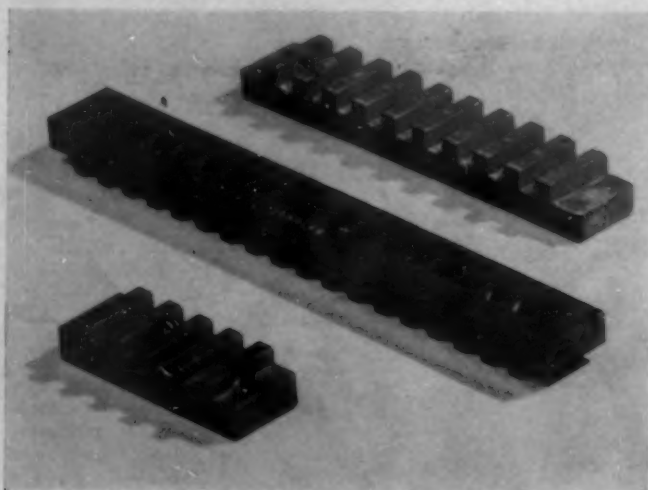
Our Southern mills have made high-tensile cotton fabrics for the Plastics Industry for fifteen years and specialty industrial cotton textiles for over thirty-five years. Our experienced development and production facilities are available to the Plastics trade, limited only by the requirements of our armed forces.

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*We offer the following raw materials:*

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Can be polymerized to form resins with exceptional bonding properties for wood, glass and metal.

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Used for the manufacture of phenolic resins and for polymerization to shellac-like products.

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Used to modify the properties of phenol-formaldehyde resins by replacement of a portion of the formaldehyde.

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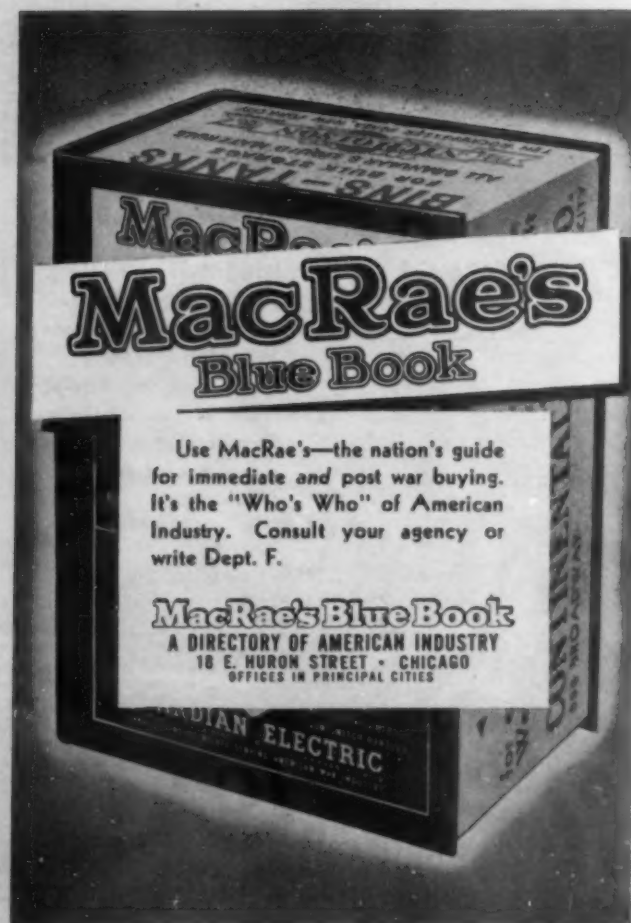
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Use MacRae's—the nation's guide for immediate and post war buying. It's the "Who's Who" of American Industry. Consult your agency or write Dept. F.

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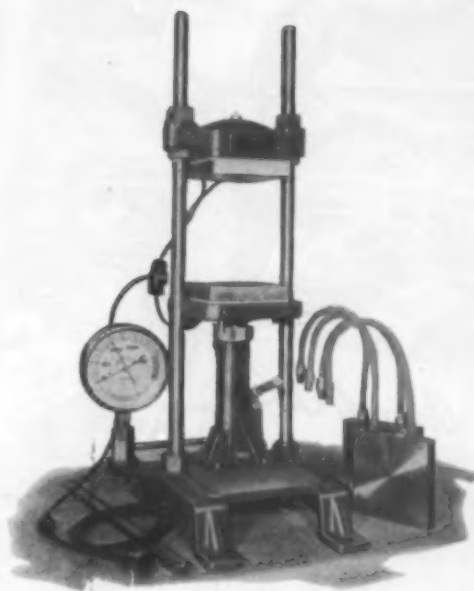
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**MINNESOTA PLASTICS  
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## THE CARVER *Laboratory* PRESS



**OUTSTANDING** improvements in plastics have originated from research and experimental work conducted with The Carver Laboratory Press. For many years this press has been widely accepted among leading companies in the plastics field.

### *It is the standard press*

- ...for making quick and accurate small-scale pressing tests.
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- ...and even for small-scale production.

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- operates with self-contained hydraulic unit.
- large accurate gauge of finest construction is rigidly mounted on base.
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Special gloves to guard the hands of  
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CUSTOM MOLDERS OF PLASTICS FOR INDUSTRY  
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## PINCH HITTERS

No pun is intended. To be sure, tubular rivets pinch tight when properly hit. But the point we hope you will discern is that the speeding up of war production has necessitated using tubular rivets in new ways to do jobs for which other fastening devices are not readily available, and in so doing have opened to resourceful production men new routes to speed strength and economy in hitherto unsuspected places.

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1. If you desire, we will be glad to discuss with you the strength, speed and economy of tubular rivets in indicated fastening jobs which you may have under consideration.
2. Arrange for after-the-war rivet supply on an "If, when and as" basis to insure quick, reliable and steady deliveries to you when the time element in peace time production will have become a crucial factor.

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**MILFORD RIVET & MACHINE CO.**

Post Road, Milford, Connecticut

and

**GENERAL RIVET & MACHINE DIVISION**

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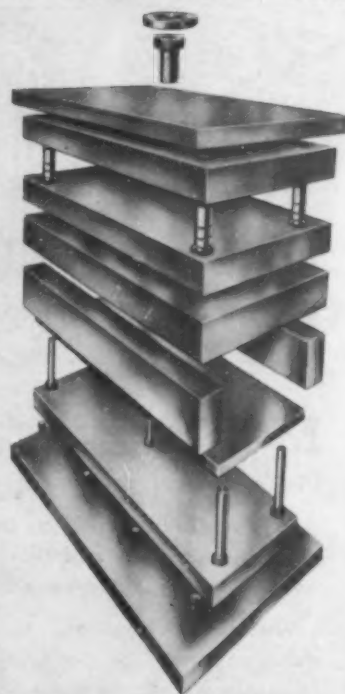
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## PARTS FOR A MOLD BASE

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Disston metallurgists and engineers will be glad to help you apply these products to your present needs—and to consult with you in confidence on postwar plans. Write fully to Henry Disston & Sons, Inc., 534 Tacony, Philadelphia 35, Pa., U. S. A.

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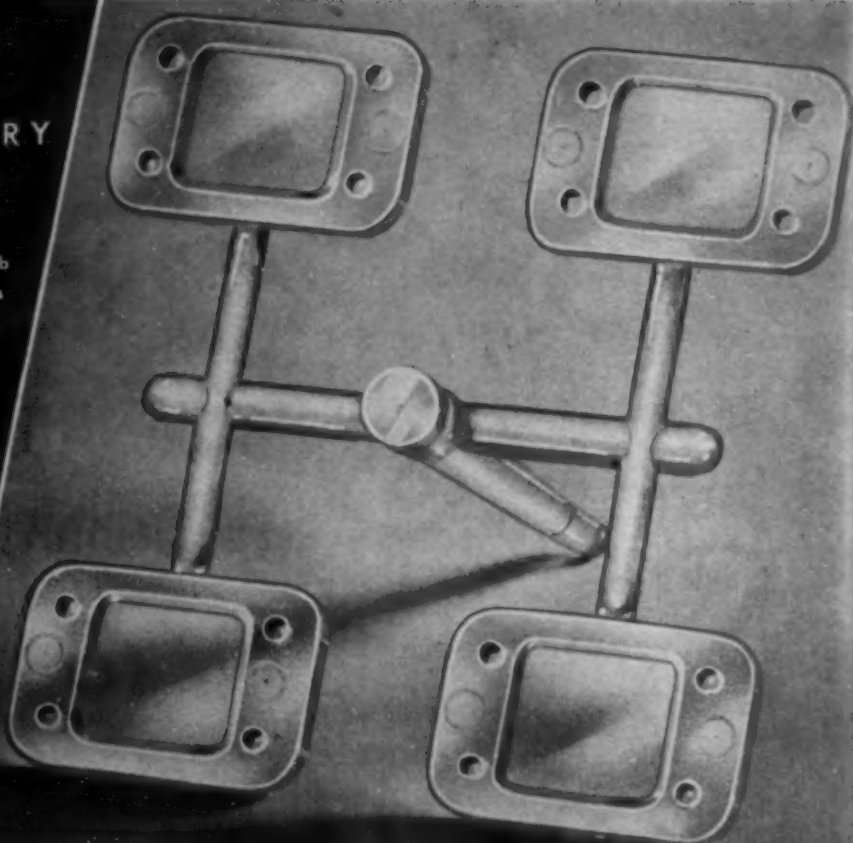
The plastic part illustrated, is doing a big job for Uncle Sam on all the war fronts and was precision-molded by Ideal for Sperry Products Corp. Because of its high standard of excellence in craftsmanship and precision-molding, Ideal has been entrusted with the manufacture of many vital plastic war products, now serving in nearly every branch of our armed forces.

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INJECTION AND EXTRUSION MOLDING



A SYMBOL OF FINEST  
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Mold • Roll • Needle  
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Bulletin 194-S gives details of these instruments.  
They help save money and make better plastics.



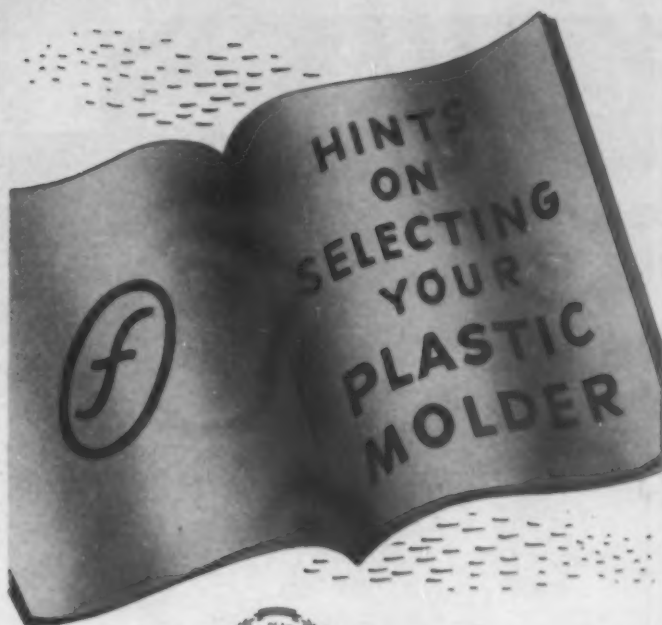
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and breaking down plastics material

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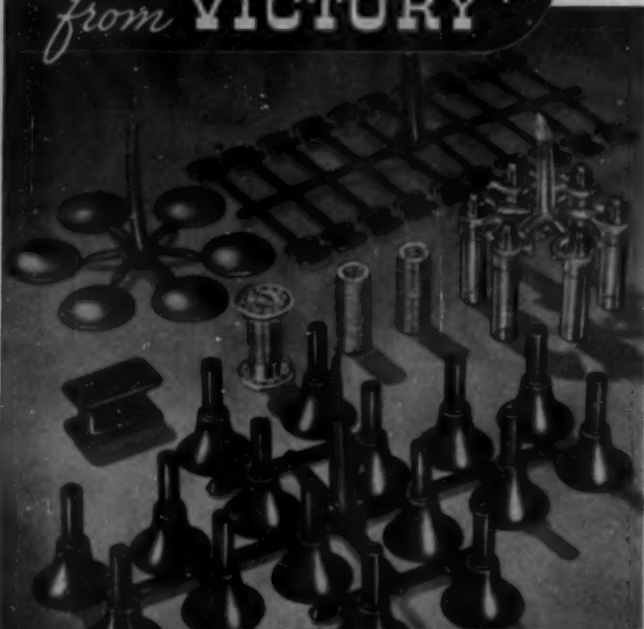


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Small and large parts

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Branded in "Deep Relief"  
for Permanence...



While Rogan did not manufacture the plastic Rain Gage illustrated at left, Rogan did perform an important function in helping to make this unit a vital instrument of war. How . . . ? By branding the graduations in *deep-relief* on the inner tube to meet most rigid government specifications.

Designed and produced by one of the nations leading molders, *Dillon-Beck Mfg. Co., Irvington, N. J.*, in collaboration with the U. S. Signal Corps, the Rain Gage is now being widely used by the armed forces to measure rainfall, so essential to the successful planning and waging of war.

Calibrating the Rain Gage to such close tolerances offers convincing proof that Rogan can do your branding on plastics, no matter how exacting your requirements may be.

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Leading the  
field for more  
than 20 years!



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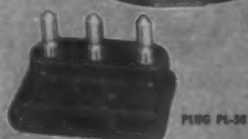
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**Interphone Equipment  
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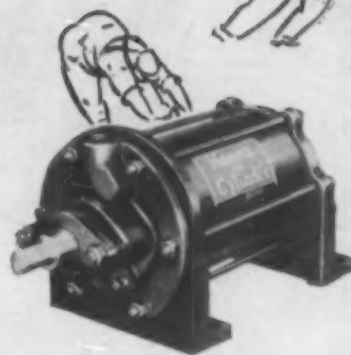
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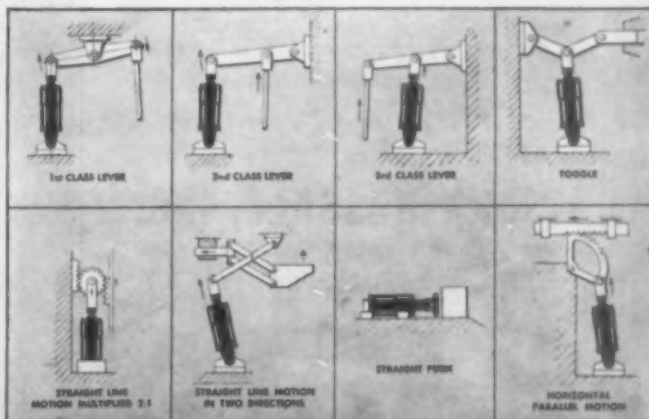
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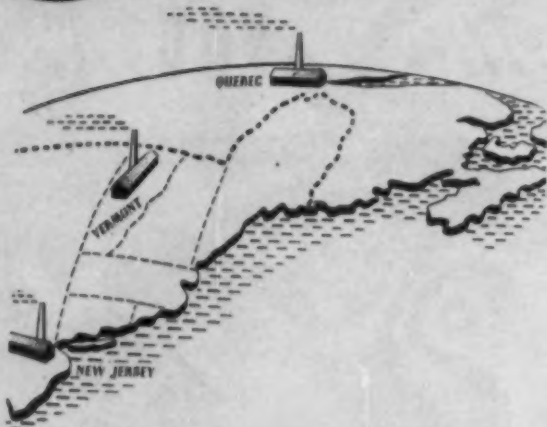
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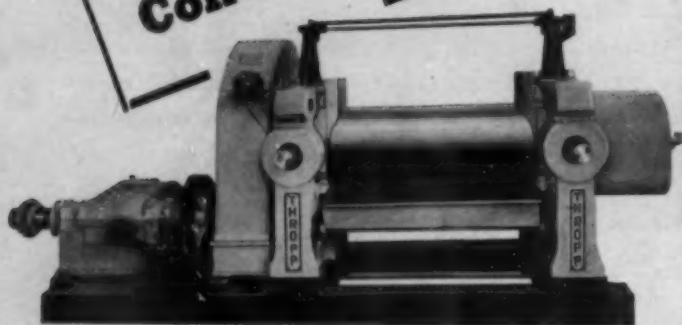
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**FOR SALE:** 1—Watson-Stillman Hydro-Accumulator, 5½" ram; 2—Farrel Birmingham Hydraulic Presses, 24 x 24, 12" ram; 1—W. S. 15" x 18" Hydraulic Press, 10" ram; 1—14" x 24" Press, 9" ram; 4—24" x 55" steel cored Heating Platens; 4—W. & P. Mixers; 1—Elmes Hydraulic Pump, 6.5 GPM at 7500 psi pressure PSI; 4—Semi-Automatic 100-ton Hydraulic Presses, platen area 20" x 36"; Adamson 6" Tuber; Dry Powder Mixers; Pulverizers, Grinders, etc. Send for complete list. Reply Box 447, Modern Plastics.

**WANTED:** Small or medium sized plastic molding plant with either hydraulic extrusion or injection equipment with or without tool shop. Advise full details. Reply Box 788, Modern Plastics.

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**MECHANICAL ENGINEER**—wanted by company established over 25 years in the Plastic Line. Must be experienced in Thermo-Plastic Field as designer of machines, molds, jigs and fixtures. Able to follow a project from drawing board to point of production. Take charge of tool room. Good opportunity and attractive salary for a man who can qualify. Plenty of Postwar business. Give full details and experience in first letter. Address P. O. Box 27, Arlington, N. J.

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Experienced in design of compression and injection molds, also jigs and fixtures. Experience in product development desirable. Box 981, Modern Plastics.

**SITUATION WANTED:** Married man, 38 years of age wishes position as press room superintendent. Over 20 years experience on compression and transfer molding, can handle all types of material, including melamine. Highest references. Location anywhere. Reply Box 979, Modern Plastics.

**FOR SALE**—Approximately 750 lbs. Crystal clear cellulose acetate tubing—O.D. 1/16" x I.D. 3/16" in 10 ft. lengths. Reply Box 980, Modern Plastics.

**FOR SALE**—Laminated plastic trim pieces; odd shapes up to 2 square feet; filler 2-ply fiberglass or 2-ply fiberglass with inner layer of duck. Plastics Division, Continental Can Company, 100 East 42nd Street, New York 17, New York.

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Plastic Injection Molding Machinery and Compression Molding Presses. Write giving details and price. Box 982, Modern Plastics.

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Familiar with plastic molding equipment for expanding factory and branch office sales of leading line of molding machinery. Box 991, Modern Plastics.

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**PLASTICS RESEARCH AND DEVELOPMENT ENGINEER** with background in chemistry and theory of plastics wanted by principals abroad for research laboratory being established to investigate adaptation and development of native natural resources (timber, minerals, agricultural products and wastes, etc.) to raw materials for plastics. Chemical engineering background essential. State fully qualifications and experience. Reply Box 993, Modern Plastics.

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Are you molding plastic parts of your own or customers, that can be sold to retail, wholesale or industrial outlets? We offer a national sales organization to assist you or your customers in marketing these products. We can market those tough ones too. Give us a try. Reply Box 994, Modern Plastics.

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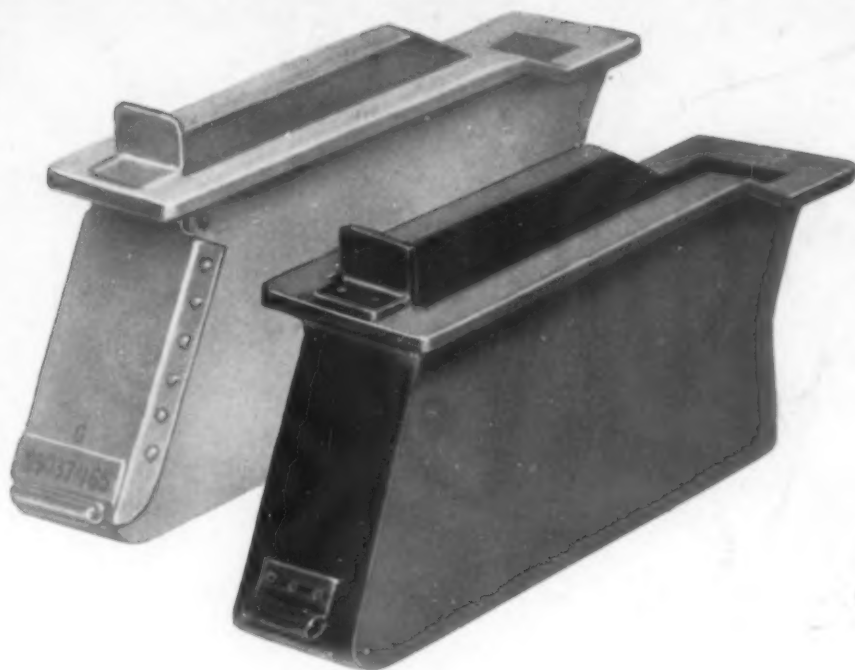
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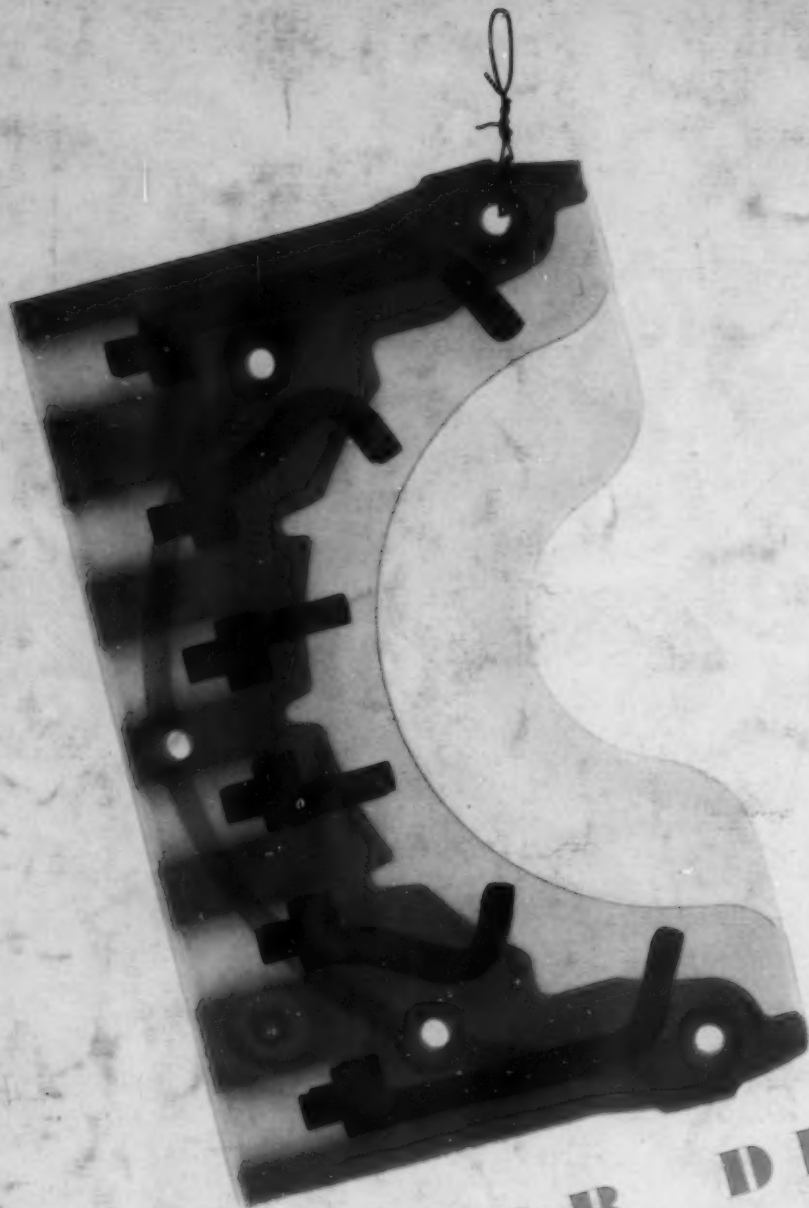
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